UNITED STATES DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

SPECIFICATION
FAA-E-2937A

CATEGORY I
LOCAL AREA AUGMENTATION SYSTEM
GROUND FACILITY

Table of Contents

Appendices

List of Illustrations

Tables

Figures

This page intentionally left blank.

1. SCOPE

1.1 IDENTIFICATION

This specification establishes the performance requirements for the Federal Aviation Administration (FAA) Category I (CAT I) Local Area Augmentation System (LAAS) Ground Facility (LGF). Requirements contained within this specification are the basis to augment the Global Positioning System (GPS) to provide precision approach capability down to Category I minimums and area navigation (RNAV). The performance requirements are consistent with the Minimum Operational Performance Standards (MOPS) for the LAAS (RTCA/DO-253A). In addition, this specification includes several functional requirements.

1.2 SYSTEM OVERVIEW

The LGF is a safety-critical system consisting of the hardware and software that augments the GPS Standard Positioning Service (SPS) providing 2-D RNAV in the terminal area and a precision approach and landing capability. The current GPS positioning service provided is insufficient to meet the integrity, continuity, accuracy, and availability demands of precision approach and landing navigation. The LGF, using differential GPS concepts, augments the GPS SPS in order to meet these requirements.

The GPS/LAAS is maintained in three separate segments; the LGF, the Space Segment, and the Airborne Subsystem as illustrated in Figure 1-1. The LGF provides differential corrections, integrity parameters, and precision approach pathpoint data that are broadcast via a Very High Frequency (VHF) Data Broadcast (VDB) to the Airborne Subsystem for processing. The Space Segment provides the LGF and Airborne Subsystem with GPS and Satellite-Based Augmentation System (SBAS) ranging signals and orbital parameters. The Airborne Subsystem applies the LGF corrections to the GPS and SBAS ranging signals to obtain position with the required accuracy, integrity, continuity, and availability. The differentially corrected position is used, along with pathpoint data, to supply deviation signals to drive appropriate aircraft systems supporting terminal area and precision approach operations. Furthermore, using the position output from the airborne receiver, LAAS augments the availability of terminal area operations for aircraft equipped with RNAV capability.

The LGF provides detailed status information to support maintenance and air traffic requirements. Status and control capabilities are executed either through a Maintenance Data Terminal (MDT) or via NAS Infrastructure Management System (NIMS). The MDT display is provided as part of the LGF; and initially, the monitoring-only capability is provided via NIMS. Additionally, the LGF sends status information to FAA Air Traffic Control (ATC) via an Air Traffic Control Unit (ATCU). The ATCU provides air traffic controllers with LGF status information and runway control capabilities. For maintenance purposes, LGF status information is available on the Local Status Panel (LSP).

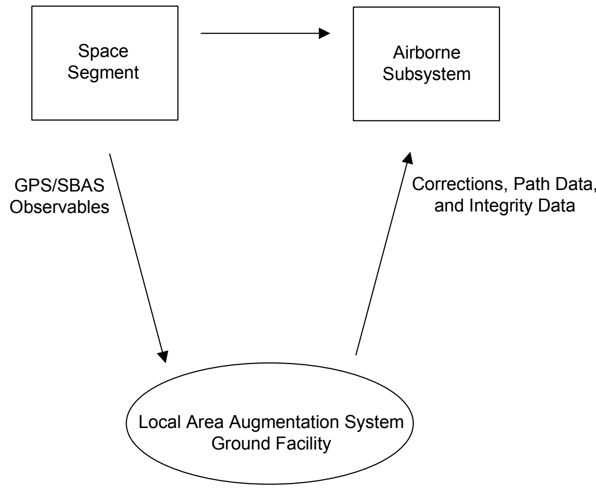


Figure 1-1. Local Area Augmentation System

1.3 DOCUMENT OVERVIEW

The format of this document complies with FAA-STD-005E, MIL-STD-961D, and MIL-STD-962C. Section 1 provides a general overview of the LGF and a high-level introduction to the requirements for implementing operational satellite-based precision approach. Section 2 lists the documents from which requirements are referenced or derived. Section 3 contains the performance, functional, operational, and maintenance requirements for the LGF. Section 4 contains verification requirements for both hardware and software. Appendix A and Appendix B are reserved. Appendix C provides a Verification Requirements Traceability Matrix. Appendix D supplies a listing and expansion of acronyms. Appendix E provides information on the Signal Deformation Threat Model. Appendix F supplies information on the usage of LGF Test and Alarm Indicators. Appendix G provides the Integrity Risk and Continuity Risk Allocation trees. Appendix H contains the definitions for the Final Approach Segment.

2. APPLICABLE DOCUMENTS

The following documents form a part of this specification and are applicable to the extent specified herein. In the event of a conflict between referenced documents and the contents of this specification, the contents of this specification shall take precedence

2.1 GOVERNMENT DOCUMENTS

2.1.1 SPECIFICATIONS

2.1.1.1 Federal Aviation Administration

Federal Aviation Administration. (2001). *Acquisition Management System, Test & Evaluation Process Guidelines.* Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (2001). *Electronic equipment, general requirements* (FAA-G-2100G). Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (2000). Code of Federal Regulations, Part 139-*Certification and Operation: Land Airports Serving Certain Air Carriers*. Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (1997). *Wide area augmentation system (WAAS) specification* (FAA-E-2892B). Washington, DC: U.S. Government Printing Office.

2.1.2 STANDARDS

2.1.2.1 Federal Aviation Administration

Federal Aviation Administration. (1996). *Standard practice preparation of specifications, standards and handbooks* (FAA-STD-005E). Washington, DC: U.S. Government Printing Office.

2.1.2.2 Military

Department of Defense. (1960). *Thread Compound; Antiseize, Zinc Dust-Petrolatum*. MIL-T-22361(1). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1966). *Insulating Compound, Electrical, Ceramic, Class L*. (MIL-I-10B). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1983). *Sealing, Locking, and Retaining Compounds: (Single -Component).* (MIL-S-22473E). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1989). *Sealing, Lubricating, and Wicking Compounds: Thread-Locking, Anaerobic, Single-Component*. (MIL-S-46163A(2)). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1995). *Department of defense standard practice for defense specifications* (MIL-STD-961D). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1995). *Department of defense standard practice defense standards and handbooks* (MIL-STD-962C). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1996). *Reliability testing for engineering development, qualification, and production.* (MIL-HDBK-781A). Washington, DC: U.S. Government Printing Office.

Department of Defense. (2000). *Navstar GPS Space Segment/Navigation User Interfaces* (ICD-GPS-200C with IRN-200C-004, 12 April 2000). Washington, DC: U.S. Government Printing Office.

Department of Defense. (2000). *Environmental Engineering Considerations and Laboratory Tests*. (MIL-STD-810F). Washington, DC: U.S. Government Printing Office.

Department of Defense. (1968). Military Specification Sheet(s) (MIL-I-23264). Washington, DC: U.S. Government Printing Office.

2.1.3 FAA ORDERS

Federal Aviation Administration. (2000). *General Maintenance Handbook for Airway Facilities.* FAA Order 6000.15C. Washington, DC: U.S. Government Printing Office.

2.1.4 OTHER GOVERNMENT DOCUMENTS

Federal Specification. (1967). *Plastic Sheet and Plastic Rod, Thermosetting, Cast* (L-P-516a). Washington, DC: U.S. Government Printing Office.

Federal Specification. (1971). *Sealing Compound, Pipe Joint and Thread, Lead Free General Purpose* (TT-S-1732). Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (1997). *NIMS manager/managed subsystem interface requirements document* (NAS-IR-51070000). Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (2001). *Interface control document, NIMS manager/managed subsystem using the simple network management protocol, version 3 (SNMPv3)* (NAS-IC-51070000-2). Washington, DC: U.S. Government Printing Office.

Department of Transportation/Federal Aviation Administration/CT-96/1. (1996). *Human Factors Design Guide for Acquisition of Commercial-Off-the-Shelf Subsystem, Non-Developmental Items, and Developmental Systems.* William J. Hughes Technical Center, Research Development and Human Factors Laboratory, Building 28, Atlantic City International Airport, NJ.

Federal Aviation Administration. (1989). Advisory Circular, *Airport Design*. (AC-150/5300-13) Washington, DC: U.S. Government Printing Office.

Federal Aviation Administration. (2002). *Statement of Work Local Area Augmentation System Ground Facility*. Washington, DC: U.S. Government Printing Office.

2.2 NON-GOVERNMENT DOCUMENTS

RTCA, Incorporated. (2001). *GNSS based precision approach local area augmentation system (LAAS) signal-in-space interface control document* (RTCA/DO-246B). Washington, DC: RTCA, Incorporated.

National Fire Protection Association. (1996). *NFPA 70, national electrical code* (1996 ed.). Quincy, MA: National Fire Protection Association.

RTCA, Incorporated. (2001). *Minimum operational performance standards for global positioning system/local area augmentation system airborne equipment* (RTCA/DO-253A). Washington, DC: RTCA, Incorporated.

RTCA, Incorporated. (2001). *Minimum operational performance standards for global positioning system/wide area augmentation system airborne equipment* (RTCA/DO-229C). Washington, DC: RTCA, Incorporated.

RTCA, Incorporated. (1992). *Software considerations in airborne systems and equipment certification* (RTCA/DO-178B). Washington, DC: RTCA, Incorporated.

3. REQUIREMENTS

This section prescribes functional and performance requirements. Functional requirements, and their groupings, do not imply allocation of functionality to hardware and software design. When required to establish interoperability, specific design and/or algorithms are specified. Certain other design-specific requirements are given, as necessary, to ensure the accuracy, continuity, availability, and integrity needed to support minimum performance levels required to operate within the U.S. National Airspace System (NAS).

3.1 LGF GENERAL REQUIREMENTS

3.1.1 COVERAGE VOLUME

The approach coverage volume for a system is defined as the volume of airspace within which the system meet the VDB field strength requirements. By meeting all of the requirements in this specification, the LGF provides the accuracy, integrity, continuity, and availability necessary to support Category I precision approach operations and RNAV operations within the coverage volume.

The LGF provides the level of service necessary to support Category I and meets the integrity to support terminal area operations. The VDB, an omnidirectional signal, accommodates terminal and surface navigation, surveillance, and other users requiring Differentially Corrected Positioning Service information. However, the use of VDB may be impacted by the existence of terrain or obstacles on or around the airport.

3.1.1.1 VDB Coverage Volume

3.1.1.1.1 Minimum Field Strength

The LGF shall meet the minimum field-strength requirements of Section 3.2.2.4 using a single VDB antenna with a phase center height no higher than 25 ft. above the ground plane. The LGF shall meet these minimum field-strength requirements (1) when there is no blockage of line-of-sight due to local terrain or obstacles, (2) when the on-channel power is set to the lower alarm limit, as specified in Section 3.2.3(b), and (3) within the following minimum coverage volume:

a. Laterally:

1. Encompassing 360° around the VDB antenna,
2. Beginning at 100 m, and
3. Extending to 23 nm,

b. Vertically, within the lateral region:

1. Within 1.5 nm of the VDB antenna, between the horizontal plane 8 ft above the ground at the antenna and a conical surface inclined at not less than 85° above the horizontal plane, up to a height of 10,000 ft, and
2. From 1.5 nm to 23 nm, between 10,000 ft AGL and a conical surface that is inclined at 0.9° above the horizontal plane with an origin 137 ft below the ground at the antenna.

3.1.1.1.2 Maximum Field Strength

The LGF shall not exceed the maximum field strength requirements of Section 3.2.2.4 in any direction, beginning at 200 m from the VDB antenna within the coverage volume specified in Section 3.1.1.1.1. The LGF shall meet these maximum field strength requirements when (1) there is no blockage of line-of-sight due to local terrain or obstacles, and (2) the on-channel power is set to the upper alarm limit.

Figure 3-2 depicts a representation of the VDB coverage volume.

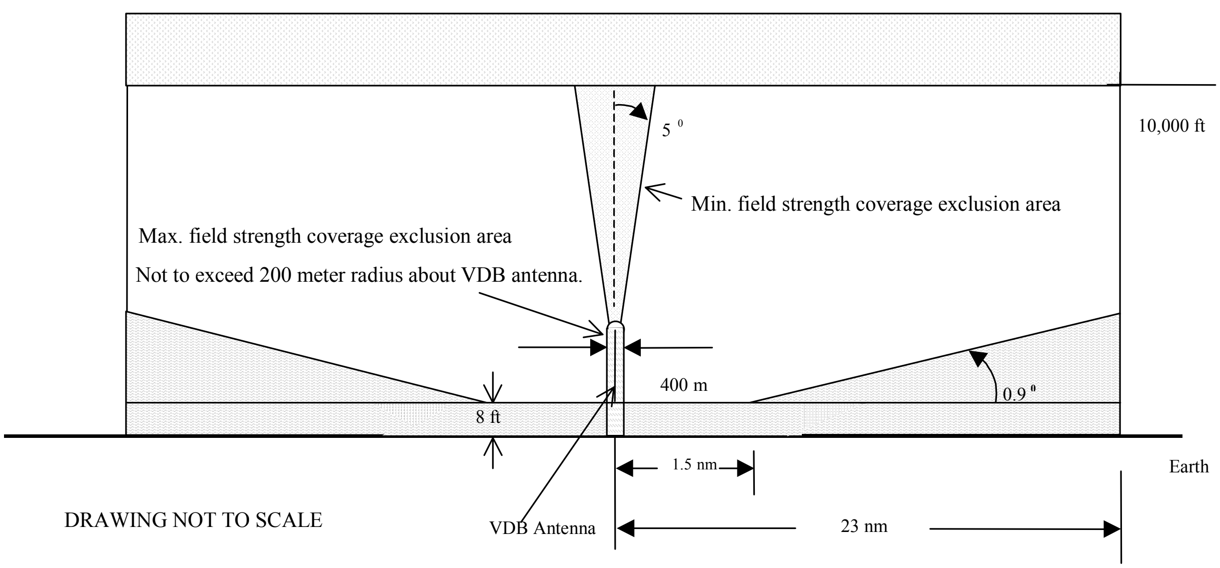


Figure 3-2. VDB Coverage Volume

3.1.2 INTEGRITY

The LGF is required to meet the integrity to support Category I precision approach, area navigation, and other operations that use differentially corrected positioning service. Some of the integrity allocations have different requirements for the operations and are specified separately in the subsections below.

3.1.2.1 LGF Integrity Risk

3.1.2.1.1 Category I Precision Approach

The probability that the LGF transmits Misleading Information (MI) for 3 seconds or longer due to a ranging source or LGF failure, when operating within the Radio Frequency Interference (RFI) environment defined in appendix D of the LAAS MOPS (RTCA/DO-253A), shall not exceed 1.5×10^{-7} during any 150-second approach interval. Misleading information is defined as broadcast data that results in a position error exceeding the protection level and ephemeris error bound for any user that complies with RTCA/DO-253A and is located anywhere within 60 nautical miles of the centroid of the reference receivers. Ranging source failures shall include:

a. Signal deformation as defined in Appendix E, with a failure rate of 1.0×10^{-4} per hour per satellite during initial acquisition, and a prior probability of 4.2×10^{-6} per approach per satellite after acquisition;

b. Signal levels below those specified in Sections 3.3.1.6 and 6.3.1 of ICD-GPS-200C, for C/A code on L1 only, with a failure rate of 1.0×10^{-4} per hour per satellite during initial acquisition, and a prior probability of 4.2×10^{-6} per approach per satellite after acquisition;

c. Code/carrier divergence, with a failure rate of 1.0×10^{-4} per hour per satellite during initial acquisition, and a prior probability 4.2×10^{-6} per approach per satellite after acquisition;

d. Excessive pseudorange acceleration, such as step or other rapid change, with a failure rate of 1.0×10^{-4} per hour per satellite during initial acquisition, and a prior probability of 4.2×10^{-6} per approach per satellite after acquisition; or

e. Erroneous broadcast of GPS ephemeris data, with a failure rate of 1.0×10^{-4} per hour per satellite during initial acquisition, and a prior probability of 4.2×10^{-6} per approach per satellite after acquisition.

The LGF failures shall include the broadcast of erroneous data, or that one or more failures exist that affect the smoothed pseudorange corrections (PR_{sca}) from more than one Reference Receiver (RR). Erroneous data is defined to be any broadcast parameter that is not computed and broadcast in accordance with Section 3.2.1. Precision Approach Misleading Information (PAMI) is defined as information that, when processed by a fault-free receiver compliant with RTCA DO-253A and DO-246B, results in an out-of-tolerance lateral or vertical relative position error.

An out-of-tolerance lateral or vertical relative position error is defined as an error that exceeds both the Category I precision approach protection level and the ephemeris error position bound.

3.1.2.1.2 Differentially Corrected Positioning Service

The probability that the LGF transmits Misleading Information (MI) for 3 seconds or longer due to a ranging source or LGF failure, when operating within the RFI environment defined in appendix D of the LAAS MOPS (RTCA/DO-253A), shall not exceed 9.9×10^{-8} during any 1-hour period. Misleading information is defined as broadcast data that results in a position error exceeding the protection level and ephemeris error bound for any user that complies with RTCA/DO-253A. Ranging source failures shall include:

a. Signal deformation as defined in Appendix E, with a failure rate of 1×10^{-4} per hour per satellite;

b. Signal levels below those specified in Sections 3.3.1.6 and 6.3.1 of ICD-GPS-200C, for C/A code on L1 only, with a failure rate of 1×10^{-4} per hour per satellite;

c. Code/carrier divergence, with a failure rate of 1×10^{-4} per hour per satellite;

d. Excessive pseudorange acceleration, such as a step or other rapid change, with a failure rate of 1×10^{-4} per hour per satellite; or

e. Erroneous broadcast of GPS ephemeris data, with a failure rate of 1×10^{-4} per hour per satellite.

The LGF failures shall include the broadcast of erroneous data, or that one or more failures exist that affect the smoothed pseudorange corrections (PR_{sca}) from more than one Reference Receiver (RR). Erroneous data is defined to be any broadcast parameter that is not computed and broadcast in accordance with Section 3.2.1. Differentially Corrected Positioning Misleading Information (DCPMI) is defined as information that, when processed by a fault-free receiver compliant with RTCA DO-253A and DO-246B, results in an out-of-tolerance horizontal relative position error. An out-of-tolerance horizontal relative position error is defined as an error that exceeds both the horizontal protection level and the horizontal ephemeris error position bound.

3.1.2.2 Protection Level Integrity Risk

In conforming to the integrity risk assigned to the LGF, the broadcast integrity parameters (B-values Section 3.2.1.2.8.8, σ_{pr_gnd} Section 3.2.1.2.8.7, $\sigma_{\_vert\_iono\_gradient}$ Section 3.2.1.3.5, P-value Section 3.2.1.2.7, K-values Section 3.2.1.3.12, Refractivity Index Section 3.2.1.3.6, Scale Height Section 3.2.1.3.7, and Refractivity Uncertainty Section 3.2.1.3.8) shall be defined to ensure proper operation under fault-free conditions (both system and local environment).

3.1.2.2.1 Category I Precision Approach

When the LGF is not broadcasting erroneous data and no failures exist that would affect the smoothed pseudorange corrections (PRsca) from more than one RR, the probability that the LGF transmits PAMI for 3 seconds or longer when operating within the Radio Frequency Interference (RFI) environment defined in appendix D of the LAAS MOPS (RTCA/DO-253A), shall not exceed 5×10^{-8} during any 150-second approach interval.

3.1.2.2.2 Differentially Corrected Positioning Service

When the LGF is not broadcasting erroneous data and no failures exist that would affect the smoothed pseudorange corrections (PRsca) from more than one RR, the probability that the LGF transmits DCPMI for 3 seconds or longer when operating within the Radio Frequency Interference (RFI) environment defined in appendix D of the LAAS MOPS (RTCA/DO-253A), shall not exceed $1x10^{-9}$ in any 1 hour interval.

3.1.2.3 Integrity in the Presence of Excessive Radio Frequency Interference (RFI)

The probability that the LGF broadcasts data that result in a position error exceeding the H_0 protection level for 3 seconds or longer (assuming use of all satellites for which the LGF provides corrections), for any user that complies with RTCA/DO-253A, in the presence of RFI that exceeds the levels in appendix D of the LAAS MOPS (RTCA/DO-253A), shall not exceed 1×10^{-3}.

3.1.3 CONTINUITY

3.1.3.1 VDB Transmission Continuity

The probability of an unscheduled interruption of the VDB transmission, where messages are not transmitted in accordance with Section 3.2.2 for a period equal to or greater than 3 seconds, shall not exceed $1x10^{-6}$ in any 15-second interval. On average, the LGF shall transmit at least 999 messages out of 1000 consecutive messages.

3.1.3.2 Reference Receiver and Ground Integrity Monitoring Continuity

The probability that the number of valid B-values is reduced below three (3) for any valid ranging source within the reception mask (Section 3.2.1.2.6.1) shall not exceed $2.3x10^{-6}$ in any 15-second interval.

3.1.4 STATES AND MODES

3.1.4.1 States

The LGF shall have the following two states:

a. LGF On: Main or supplemental power is applied to the LGF equipment, and

b. LGF Off: No power is applied to the LGF equipment.

Only one state shall exist at a time.

3.1.4.2 Modes

The LGF shall have the following modes while in the On State:

a. Normal,

b. Not Available, and

c. Test.

There are no modes when the LGF is in the Off State.

Only one mode shall exist at a time. The LGF shall automatically transition from Normal to Not Available when there is an alarm condition.

3.1.4.3 Normal Mode

The LGF shall be in the Normal Mode when Test Mode has not been commanded and an alarm does not exist. The Normal Mode shall include the following conditions, actions and transition criteria:

a. Conditions:

   1. Alert (Section 3.1.5.1.2)
   2. Service Alert (Section 3.1.5.1.3)
   3. Constellation Alert (Section 3.1.5.1.4)

b. Actions:

   1. Approach Control (Section 3.3.2.3.1)
   2. Periodic Maintenance (Section 3.3.1.7.3.2)
   3. Non-intrusive diagnostics (Section 3.3.2.2.19)
   4. LRU Replacement (Section 3.3.1.7.3.1)
   5. Data Recording (Section 3.3.3)
   6. Status monitoring (Sections 3.3.2.2.2, .3, .4, .7 - .9, .12, .14, .16, .18, .20, .22, & .23)
   7. User ID and password change (Sections 3.3.1.8.1.1.1 and 3.3.1.8.1.3.3)
   8. Adjustment storage (Section 3.3.2.2.21)
   9. Fault recovery (Section 3.1.5.1.1)
   10. Audit log file archiving (Section 3.3.1.8.4.3)

c. Transition Criteria:

   1. Entering Normal Mode:
      a) Enter Normal Mode from Off State (power applied)
      b) Enter Normal Mode from Test Mode (Normal Mode commanded)
      c) Enter Normal Mode from Not Available Mode (Auto restart or manual restart commanded)
   2. Exiting Normal Mode:

a) Exit Normal Mode to Not Available Mode (alarm)

b) Exit Normal Mode to Test Mode (Test Mode commanded)

3.1.4.4 Not Available Mode

The LGF shall transition from the Normal Mode to the Not Available Mode when an alarm exists and when it is not in Test Mode. The LGF shall remain in the Not Available Mode until the alarm is cleared or the LGF is placed in the Test Mode. The Not Available Mode shall include the following conditions, actions and transition criteria:

a. Condition:
   1. Alarm (Section 3.1.5.1.5)
b. Actions:
   1. Automatic Restart (Section 3.1.5.1.5.1)
   2. States and modes display (Section 3.1.4)
   3. System power display (Section 3.3.2.2.7)
   4. System events recording (Section 3.3.3.1)
c. Transition Criteria:
   1. Entering Not Available Mode:
      a) Enter Not Available Mode from Normal Mode (alarm)
      b) Enter Not Available Mode from Test Mode (alarm)
   2. Exiting Not Available Mode:
      a) Exit Not Available Mode to Normal Mode (auto restart or manual restart commanded)
      b) Exit Not Available Mode to Test Mode (Test Mode commanded)

3.1.4.5 Test Mode

The LGF shall enter the Test Mode when commanded. While in the Test Mode, the VDB shall be capable of broadcasting all message types as if in the Normal or the Not Available Mode, as required in Section 3.2.1.1.1. The Test Mode shall include the following conditions, actions and transition criteria:

a. Conditions:
   1. Alert (Section 3.1.5.1.2)
   2. Service Alert (Section 3.1.5.1.3)
   3. Constellation Alert (Section 3.1.5.1.4)
   4. Alarm (Section 3.1.5.1.5)
b. Maintenance and test actions:

1. Restart the LGF (Section 3.3.2.2.1)
2. Intrusive and non-intrusive diagnostic control (Section 3.3.2.2.19)
3. Trouble shooting (Section 3.3.1.6)
4. Site specific parameter change (Sections 3.3.2.2.6 & 3.3.2.2.13)
5. Alert, service alert, constellation alert, and alarm threshold change (Section 3.3.2.2.10)
6. Redundant equipment status change (Section 3.3.2.2.17)
7. Monitor by-pass (Section 3.3.2.2.11)
8. VDB by-pass (Section 3.3.2.2.5)
9. Approach control (Section 3.3.2.3.15 & 3.3.2.3.1)
10. Periodic maintenance (Section 3.3.1.7.3.2)
11. LRU replacement (Section 3.3.1.7.3.1)
12. Data recording (Section 3.3.3)
13. Status monitoring (Sections. 3.3.2.2.2, .3, .4, .7 - .9, .12, .14, .16, .18, .20, .22, & .23)
14. User ID and password change (Sections 3.3.1.8.1.1.1 and 3.3.1.8.1.3.3)
15. Adjustment storage (Section 3.3.2.2.21)
16. Fault recovery (Section 3.1.5.1.1)
17. Audit log file archiving (Section 3.3.1.8.4.3)

c. Transition Criteria:

1. Entering Test Mode:
   a) Enter Test Mode from Normal Mode (Test Mode commanded)
   b) Enter Test Mode from Not Available Mode (Test Mode commanded)
2. Exiting Test Mode:
   a) Exit Test Mode to Normal Mode (Normal Mode commanded)
   b) Exit Test Mode to Not Available Mode (alarm)

Upon exiting the Test Mode, the LGF shall revert to either the Normal or the Not Available Mode, depending on the existence of an alarm.

The following figure, Figure 3-3, illustrates the allowable conditions and actions within LGF States and Modes.

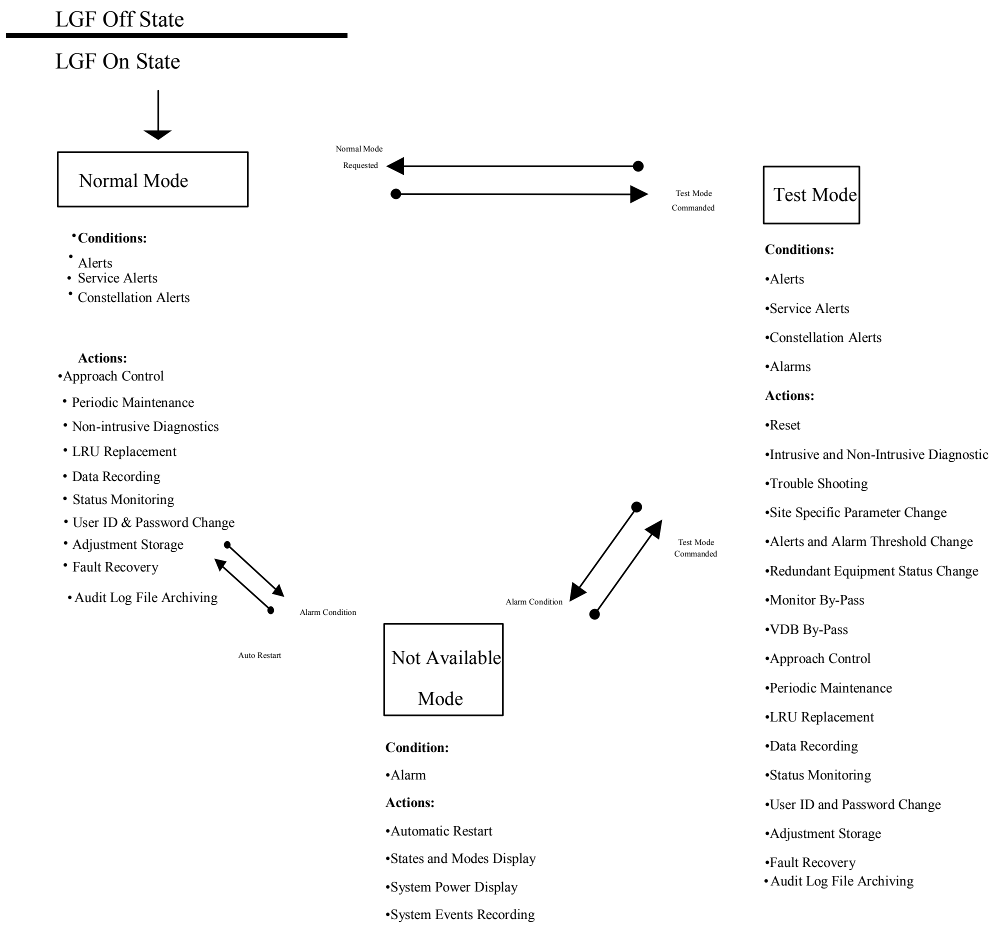


Figure 3-3. Local Area Augmentation System: States and Modes

3.1.5 EXECUTIVE MONITORING

3.1.5.1 Fault Monitoring

The LGF shall take the identified action for each fault condition identified in Table 3-1 and Table 3-2.

Table 3-1. Fault Conditions and Actions

Section	Fault	Action
Ranging Source		
3.1.2.1.1(a)/ 3.1.2.1.2 (a)	Signal Deformation	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.1.2.1.1(b)/ 3.1.2.1.2 (b)	Low Signal Power	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.1.2.1.1(c)/ 3.1.2.1.2 (c)	Code/Carrier Divergence	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.1.2.1.1(d)/ 3.1.2.1.2 (d)	Excessive Acceleration	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.1.2.1.1(e)/ 3.1.2.1.2 (e)	Erroneous Ephemeris	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
3.2.1.2.8.3.3	Invalid GPS C/A Code	Exclude Ranging Source Measurement Block from Type 1 Message Broadcast and the clock correction (S_c).
Corrections		
3.2.1.2.8.7	Filters not converged	Exclude PR_{mn}[1] from PRC and B-value calculation, exclude ranging source from Type 1 Message broadcast.
3.2.1.2.8.8.1	B-value exceeds limit	Exclude PR_{mn}[1] from PRC and B-value calculation.
3.2.1.2.8.5.6.1	Pseudorange correction exceeds limit	Exclude ranging source from Type 1 Message broadcast.
3.2.1.2.8.5.6.1	Navigation data inconsistent between RRs	Exclude ranging source from Type 1 Message broadcast.
3.2.1.2.8.6.1	Range Rate Correction (RRC) exceeds limit	Exclude ranging source from Type 1 Message broadcast.
3.2.1.2.8.7.3	Faulted σ_{pr_gnd}	Exclude PR_{mn}[1] from PRC and B-value calculation, exclude ranging source from Type 1 Message broadcast, or exclude all measurements from RR from PRC and B-value calculation.
3.2.1.3.5.1	Faulted $\sigma_{vert\_iono\_gradient}$	Exclude ranging source from Type 1 Message broadcast, or exclude all measurements from RR from PRC and B-value calculation.
RFI		
3.1.2.3	Excessive RFI	Exclude affected measurements from calculations and/or Type 1 Message Broadcast, as appropriate.
Data Broadcast		
3.2.3 (a)	Disagreement between transmitted data	Terminate VDB output.
3.2.3 (b) (c)	On-channel assigned power does not meet, or exceeds limits	Terminate VDB output.
3.2.3 (d)	More than 0.2% of messages not transmitted in last hour	Terminate VDB output.
3.2.3 (e)	No transmission for 3 seconds	Terminate VDB output.
3.2.3 (f)	Transmitted data outside of assigned Time Division Multiple Access (TDMA) time slots	Terminate VDB output.

[1] *Pseudorange (PR), where m indicates an individual RR and n indicates an individual ranging source.*

Table 3-2. Valid GPS and SBAS Navigation Data

Section	Fault	Action
3.2.1.2.8.3.1:		
(a)	Failed parity	Exclude GPS ranging source from Type 1 Message broadcast
(b)	Bad IODC	Exclude GPS ranging source from Type 1 Message broadcast
(c)	HOW bit 18 set to "1"	Exclude GPS ranging source from Type 1 Message broadcast
(d)	Data bits in subframes 1, 2, or 3 set to "0"	Exclude GPS ranging source from Type 1 Message broadcast
(e)	Subframes 1, 2, or 3 set to default	Exclude GPS ranging source from Type 1 Message broadcast
(f)	Preamble incorrect	Exclude GPS ranging source from Type 1 Message broadcast
(g)	Almanac differs from ephemeris by more than 7000 m at any point	Exclude GPS ranging source from Type 1 Message broadcast
(h)	Receive "Do Not Use" SBAS message	Exclude GPS ranging source from Type 1 Message broadcast
(i)	Ephemeris CRC changes and IODE does not	Exclude GPS ranging source from Type 1 Message broadcast
(j)	GPS PRN = 33 - 37	Exclude GPS ranging source from Type 1 Message broadcast
(k)	Satellite declared unhealthy	Exclude GPS ranging source from Type 1 Message broadcast
3.2.1.2.8.3.1	Ephemeris not consistent to within 250 m	Exclude GPS ranging source from Type 1 Message broadcast
3.2.1.2.8.3.2:		
(a)	Failed parity	Exclude SBAS ranging source from Type 1 Message broadcast
(b)	Almanac differs from ephemeris by more than 200 km at any point	Exclude SBAS ranging source from Type 1 Message broadcast
(c)	No SBAS navigation message for 4 minutes	Exclude SBAS ranging source from Type 1 Message broadcast
(d)	Receive 'Do Not Use" SBAS message	Exclude SBAS ranging source from Type 1 Message broadcast

3.1.5.1.1 Fault Recovery

Upon exclusion of a single measurement, ranging source, or RR, the LGF shall continue to monitor the excluded single measurement, ranging source, or RR. For ranging source faults and correction faults in Table 3-1, except as noted in Section 3.2.1.2.8.7.3, the LGF shall re-introduce the excluded single measurement, ranging source, or RR when the fault no longer exists. The LGF shall use a probability of missed detection consistent with an apriori failure probability of one for excluded single measurement on a ranging source to meet LGF integrity risks in Section 3.1.2.

3.1.5.1.2 Generation of Alerts

The LGF shall generate an alert upon detecting a fault that does not affect the ability of the system to meet the integrity requirements of Section 3.1.2. Faults shall include the ranging source and correction faults identified in Table 3-1, navigation data in Table 3-2, environmental sensor conditions exceeding the limits defined in Sections 3.3.1.5.3, and 3.3.1.5.5, and denial of access event defined in Section 3.3.1.8.1.2.1.2.

3.1.5.1.3 Generation of Service Alerts

A service alert shall be defined as a fault that requires corrective maintenance.

3.1.5.1.3.1 Continuity Faults

A service alert shall be generated when the LGF is unable to ensure that the continuity requirements of Section 3.1.3 can be met due to a fault in either of the following items:

a. Main and standby Line Replaceable Units (LRUs), or

b. Uninterruptible power supply.

3.1.5.1.3.2 Environmental Faults

A service alert shall be generated when the thresholds for the following environmental sensors are exceeded:

a. Intrusion detector (Section 3.3.1.5.1),

b. Smoke detector (Section 3.3.1.5.2),

c. Alternating Current (AC) power (Section 3.3.1.5.4), and

d. Inside temperature (Section 3.3.1.5.5).

3.1.5.1.4 Generation of Constellation Alerts

A constellation alert shall be generated when the constellation no longer supports CAT I service, or is predicted not to support CAT I service. The predictive constellation alert shall be generated prior to the loss of service availability in accordance with the following:

a. Constellation alerts shall be based on aircraft equipage with Aircraft Accuracy Designator stored in NVM (Section 3.3.2.2.24), the σ_{pr_gnd} achieved by the installed and operating LGF (including the number of operating RRs), and assuming standard interference environment defined in Appendix D of RTCA/DO-253A.

b. The constellation alert shall be generated by comparing the Precision approach Protection Level equations for Hypothesis H_o (VPL H_o and LPL H_o) for all in view GPS and SBAS satellites, to their tightest alert limits as indicated by FASVAL and FASLAL in Section 3.3.2.2.6. Numerical values of VPL H_o and LPL H_o shall be generated in accordance with RTCA DO-253A. In numerical evaluation of VPL H_0 and LPL H_0, the LGF shall not use information or measurements from satellites that are:

1. Flagged unhealthy by Operational Control Segment (OCS).
2. Flagged unhealthy in its transmitted message.
3. Currently excluded by the LGF.
4. Scheduled to be unavailable (via Notice to Airman NOTAM).

c. The constellation alert shall be generated with respect to the centroid of the reference receiver locations.

d. Constellation alert generation shall include effect of reception masking, as defined in section 3.2.1.2.6.1.

e. Constellation alert generation shall use current ephemeris for all visible satellites within the reception mask. For all satellites entering the reception mask, most recent almanac shall be used.

The period over which this prediction is made shall be from the current time to a time that is configurable up to 30 minutes.

3.1.5.1.5 Generation of Alarms

The LGF shall generate an alarm when the integrity requirements of Section 3.1.2 are not met. The LGF shall generate an alarm when the VDB monitor has detected any fault identified in Section 3.2.3. When an alarm is generated, one of the following actions is taken:

a. The LGF shall broadcast the Type 1 Message with no measurement blocks when the integrity requirements of Section 3.1.2 cannot be met.

b. When there is a fault detected in accordance with the requirements of Section 3.2.3, the LGF shall terminate the VDB output.

Alarm thresholds shall be stored in NVM, and the default thresholds shall be defined during the design process.

3.1.5.1.5.1 Automatic Restart

The LGF shall attempt an automatic restart, except as specified in Section 3.2.1.2.8.7.3, within 3 minutes following an alarm. If an alarm condition still exists following the restart attempt, restart shall be available only through manual command via the MDT (Section 3.3.2.2.1).

3.1.6 SOFTWARE DESIGN ASSURANCE

All LGF software functions shall be compliant with the guidelines and objectives of the applicable software level specified in "Software Considerations in Airborne Systems and Equipment Certification" (RTCA/DO-178B, 1992).

All software developed for this system shall be in accordance with the C programming language specified in ANSI/ISO/IEC 9899-1999.

Note: The use of any other programming language will be subject to Government approval.

3.1.7 COMPLEX ELECTRONIC HARDWARE DESIGN ASSURANCE

Electronic hardware is complex when its normal operation has a multiplicity of states, and its design must be constrained to ensure that failures or errors in a normal operational state have a one-to-one mapping to failure conditions or failure modes. The design of complex electronic hardware devices, including Application Specific Integrated Circuits (ASIC) and Programmable Logic Devices (PLD), shall be constrained to ensure deterministic behavior with one-to-one mapping of failures to failure modes. The level of design assurance required shall be based on the complexity of the device and its contribution to potential failure conditions that adversely affect the safety of the system.

The level of production process rigor associated with complex electronic hardware shall be based on the contribution of the hardware to potential failure conditions as determined by the System Safety Assessment (SSA) process.

3.2 DATA BROADCAST

3.2.1 BROADCAST DATA REQUIREMENTS

All message types shall be in accordance with Section 2.4 of RTCA/DO-246B. All static parameters to be broadcast and default values shall be stored in the LGF Non-Volatile Memory (NVM).

3.2.1.1 LAAS Message Block

The LGF shall transmit the LAAS message block. The LAAS message block consists of the Message Block Header, the Message, and the Cyclic Redundancy Check (CRC).

3.2.1.1.1 Message Block Header

3.2.1.1.1.1 Message Block Identifier

The LGF shall set the Message Block Identifier Field to 1010 1010 when the LGF is not in the Test Mode.

The LGF shall set the Message Block Identifier Field to 1111 1111 when the LGF is in the Test Mode.

3.2.1.1.1.2 Ground Station Identification

The GBAS ID Field shall denote the LGF station Identification (ID) stored in LGF NVM.

3.2.1.1.1.3 Message Type Identifier

The Message Type Identifier Field shall denote the Message Type.

3.2.1.1.1.4 Message Length

The Message Length Field shall denote the number of 8-bit words in the message block. The message length includes the header, the message, and the CRC field.

3.2.1.1.2 Cyclic Redundancy Check (CRC)

The CRC Field shall denote the CRC calculated on the message header and the message.

3.2.1.2 Type 1 Message – Differential Corrections

The LGF shall broadcast the Type 1 Message a minimum of once per frame from each VDB antenna. The LGF shall broadcast the Type 1 Message a maximum of once per slot including transmissions from all VDB antennas. If the Type 1 Message is broadcast in different slots within a frame, the modified Z-count shall not change, and the measurement block shall contain the same data.

The LGF shall generate a ranging source measurement block for all ranging sources when available within the reception mask. The LGF shall accommodate up to 18 ranging sources.

Note: Antenna Diversity is defined as the use of multiple VDB antennas to provide the coverage required at a given airport.

3.2.1.2.1 Modified Z-Count

The Modified Z-count shall indicate the time of the pseudorange measurements (PR_r in Section 3.2.1.2.8.5.1) and phase measurement (ϕ in Section 3.2.1.2.8.5.1) to within 0.05 seconds. The broadcast corrections shall be broadcast within 1.25 seconds after the time indicated by the Modified Z-count corresponding to the broadcast corrections.

3.2.1.2.2 Additional Message Flag

The Additional Message Flag Field shall denote that additional messages are not provided.

3.2.1.2.3 Number of Measurements

The Number of Measurements Field shall denote the number of ranging source measurement blocks broadcast in the Type 1 Message.

3.2.1.2.4 Measurement Type

The Measurement Type Field shall denote the measurement type is C/A code.

3.2.1.2.5 Ephemeris CRC

The Ephemeris CRC Field shall denote the CRC for the ranging source associated with the first ranging source measurement block in the Type 1 Message.

3.2.1.2.6 Source Availability Duration

The Source Availability Duration Field shall denote the period that the ranging source is predicted to remain within the reception mask associated with the first ranging source measurement block relative to the Modified Z-count. The accuracy of the calculated Source Availability Duration shall be better than +/- 60 seconds for all source availability duration less than the maximum range of the Source Availability Duration Field.

3.2.1.2.6.1 Reception Mask

The reception mask for each RR shall define the region in which the RR can provide sufficient data to the LGF such that measurement blocks can be calculated. The reception mask shall include all elevations from 5^o to 90^o and all azimuths from 0^o to 360^o, excluding blockage of line-of-site due to any permanent obstacle. The RR antenna shall have at least 0 dBi gain at 5^o elevation and no more than –10 dBi gain at 0.5^o elevation. The antenna gain shall monotonically decrease from 5^o elevation to 0^o elevation at a rate of not less than 2dB per degree.

3.2.1.2.6.2 Azimuth/Elevation Sector Masking

The LGF shall have the capability to exclude measurements from the pseudorange correction calculation within azimuth/elevation sector(s) on a per RR basis. The resolution of the azimuth and elevation limits shall be 0.1 degrees. The azimuth/elevation sector mask(s) shall be stored in the LGF NVM.

3.2.1.2.7 Ephemeris Decorrelation Parameter (P)

The Ephemeris Decorrelation Parameter field shall characterize the impact of residual ephemeris errors due to spatial decorrelation for the ranging source, associated with the first ranging source measurement block, in the Type 1 message. For every valid GPS ranging source, the LGF shall broadcast a *P*-value to represent the impact of undetected ephemeris errors on user range error. The maximum value for *P* shall be 1.5×10^{-4} m/m. The LGF shall exclude any ranging source for which the *P*-value cannot be validated. The broadcast ephemeris *P*-value for a given satellite shall account for the condition where the broadcast reference point (Section 3.2.1.3.9) does not match the reference receiver centroid location. When a healthy SBAS ranging source is within the reception mask, the impact of SBAS ephemeris monitoring shall be reflected in the *P*-values for all ranging sources included in the SBAS messages broadcast by this ranging source (except those indicated as "Do Not Use", which must be excluded per Section 3.2.1.2.8.3.1(h). When a healthy SBAS ranging source is not available within the reception mask, the *P*-values shall be based on GPS SPS signals.

3.2.1.2.8 Ranging Source Measurement Block

The first ranging source in the message shall sequence so that the ephemeris decorrelation parameter, the ephemeris CRC, and source availability duration for each ranging source is transmitted at least once every 10 seconds from each VDB antenna, except when new ephemeris data are received from a ranging source. When new ephemeris data are received from a ranging source, the LGF shall broadcast the new ephemeris data for that ranging source in three consecutive Type 1 Messages from each VDB antenna. When new ephemeris data are received from more than one ranging source, the first ranging source in the Type 1 Message shall sequence so that the ephemeris decorrelation parameter, the ephemeris CRC, and source availability duration for each ranging source are transmitted at least once every 27 seconds from each VDB antenna.

3.2.1.2.8.1 Ranging Source Identification

The Ranging Source ID Field shall denote the satellite pseudorandom number assigned to the ranging source associated with the ranging source measurement block.

3.2.1.2.8.2 Ranging Signal Sources

The LGF shall be capable of processing:

a. GPS SPS signals, as defined in the ICD-GPS-200C and the SPS Performance Standard, and

b. SBAS signals, as defined in the Wide Area Augmentation System (WAAS) Specification (FAA-E-2892B).

3.2.1.2.8.3 Conditions for Transmitting the Ranging Source Measurement Block

The LGF shall cease broadcast of a failed ranging source measurement block within 3 seconds of the onset of the associated ranging source failures, as specified in Sections 3.1.2.1.1 and 3.1.2.1.2.

3.2.1.2.8.3.1 Valid GPS Navigation Data

The LGF shall cease broadcast of the ranging source measurement block associated with a given ranging source if:

a. Three or more parity errors have been detected from multiple receivers in the previous 6 seconds, in accordance with the parity algorithm equations defined in Section 20.3.5, 20.3.5.1, and 20.3.5.2 of ICD-GPS-200C,

b. Broadcast Issue of Data (IOD) Ephemeris (IODE) does not match eight least-significant bits of broadcast IOD Clock (IODC),

c. Bit 18 of the Hand-over-Word (HOW) is set to 1 (Section 20.3.3.2 of ICD-GPS-200C),

d. All data bits are zeros in sub-frames 1, 2, or 3,

e. Default navigation data are being transmitted in sub-frames 1, 2, or 3 (Section 20.3.2 of ICD-GPS-200C, for C/A code on L1 only),

f. The preamble does not equal 8B (hexadecimal),

g. At any time in the next 12 hours, any point on the orbit defined by the broadcast ephemeris is more than 7000 m from the orbit defined by the broadcast almanac,

h. An SBAS within the reception mask broadcasts a Message Type 2, 3, 4, 5, 6, or 24 indicating "Do Not Use This GPS Satellite" as defined in Section 2.1.1.4 of RTCA/DO-229C, provided that no more than two ranging sources are so designated by SBAS at any one time, while the health bits in sub-frame 1 word 3 indicate that the satellite is healthy,

i. The ephemeris CRC changes and the IODE does not,

j. The PRN is 33, 34, 35, 36, or 37, or

k. The health bits in sub-frame 1 word 3 indicate that the satellite is unhealthy.

A new ephemeris shall be compared to the previously broadcast ephemeris, if available, and is validated if the difference in satellite position is less than 250 m and none of the conditions in (a) through (k) exists. Ephemerides shall be validated and applied within 3 minutes of receiving a new set, but not before they have been continuously present for 2 minutes.

3.2.1.2.8.3.2 Valid SBAS Navigation Data

The LGF shall cease broadcast of the ranging source measurement block associated with a given ranging source if:

a. Three or more parity errors have been detected from multiple receivers in the previous 6 seconds, in accordance with the parity algorithm equations defined in Appendix 2, Section 4.3.3 of FAA-E-2892B,

b. The satellite position defined by the broadcast ephemeris is more than 200 km from the satellite position defined by the broadcast almanac,

c. More than 4 minutes have elapsed since reception of the SBAS Type 9 navigation message, or

d. The SBAS satellite, for which the ranging source measurement block provides a correction, broadcasts a Message Type 0 indicating "Do Not Use This SBAS Signal" within the last 60 seconds, a Message Type 2, 3, 4, 5, 6, or 24 indicating "Do Not Use This SBAS Satellite" within the last 6 seconds, or if its User Range Accuracy (URA) in Message 10 indicate "Unbounded Ranging", as defined in Section 2.1.1.4 of RTCA/DO-229C.

After confirming that none of the conditions in (a) through (d) exists, new SBAS navigation data shall be used for subsequent measurements.

3.2.1.2.8.3.3 Invalid GPS C/A Code

The LGF shall cease broadcast of the ranging source measurement block if non-standard C/A code (NSC) is transmitted for that satellite, as described in Section 3.2.1 of ICD-GPS-200C.

3.2.1.2.8.4 Issue of Data

The IOD Field shall denote the IODE for GPS associated with the ephemeris data used to determine the broadcast correction, or 1111 1111 for SBAS.

3.2.1.2.8.5 Pseudorange Corrections

The Pseudorange Correction Field shall denote the broadcast pseudorange correction.

3.2.1.2.8.5.1 Smoothed Pseudorange

In steady state, each pseudorange measurement from each RR shall be smoothed using the filter

$$PR_s(k) = \left(\frac{1}{N}\right) PR_r(k) + \left(\frac{N-1}{N}\right)\left[PR_s(k-1) + \phi(k) - \phi(k-1)\right]$$
$$N = S/T \qquad (1)$$

where PR_r is the raw pseudorange,

PR_s is the smoothed pseudorange,

N is the number of samples,

S is the time filter constant, equal to 100 seconds, *T* is the filter sample interval, nominally equal to 0.5 seconds and not to exceed 2 seconds. *T* shall not exceed 0.5 seconds more than once during every 60-second interval,

ϕ is the accumulated phase measurement,

k is the current measurement, and

k-1 is the previous measurement.

The raw pseudorange shall be determined under the following conditions:

a. The code loop is carrier driven and of first order, or higher, and has a one-sided noise bandwidth ≥ 0.125 Hz.

b. The strongest correlation peak is acquired.

Note: The requirement for T allows compensation for a momentary loss of signal to ensure continuity for valid ranging sources.

3.2.1.2.8.5.2 GPS Predicted Range

The predicted range to each GPS ranging source shall be computed from the corresponding RR antenna-phase center location and the validated ephemeris. The ephemeris shall be determined in accordance with Section 20.3.3.4.3 of ICD-GPS-200C.

3.2.1.2.8.5.3 SBAS Predicted Range

The predicted range to each SBAS ranging source shall be computed from the corresponding RR antenna-phase center location and the validated ephemeris. The position of the ranging source shall be determined in accordance with Section 2.1.1.4.6 of RTCA/DO-229C.

3.2.1.2.8.5.4 GPS Smoothed Pseudorange Correction

The smoothed pseudorange correction (PR_{sc}) for a GPS ranging source shall be calculated using the equation:

$$PR_{sc}(n,m) = R(n,m) - PR_s(n,m) - t_{sv\_gps}(n) \qquad (2)$$

where R is the predicted range;
n is the satellite index;
m is the RR index;
$t_{sv\_gps}(n)$ is the correction due to the satellite clock from the decoded GPS Navigation Data in accordance with Sections 3.3.1.7 and 20.3.3.3.1.9, and algorithms given in Section 20.3.3.3.3 of ICD-GPS-200C, for C/A code on L1 only.

Ionospheric and tropospheric corrections shall not be applied to the smoothed pseudorange correction.

3.2.1.2.8.5.5 SBAS Smoothed Pseudorange Correction

The smoothed pseudorange correction (PR_{sc}) for an SBAS ranging source shall be calculated using the equation:

$$PR_{sc}(n,m) = R(n,m) - PR_s(n,m) - t_{sv\_sbas}(n) \qquad (3)$$

where $t_{sv\_sbas}(n)$ is the correction due to the satellite clock from the decoded WAAS Navigation Data Message Type 9 in accordance with the algorithm given in Section 2.1.1.4.6 of RTCA/DO-229C.

3.2.1.2.8.5.6 Broadcast Correction

The broadcast correction shall be calculated using the equations:

$$PR_{corr}(n) \equiv \frac{1}{M(n)} \sum_{m \in s_n} PR_{sca}(n,m) \text{ and} \qquad (4)$$

$$PR_{sca}(n,m) \equiv PR_{sc}(n,m) - \frac{1}{N_c} \sum_{n \in s_c} PR_{sc}(n,m). \qquad (5)$$

where: PR_{corr} is the broadcast correction,

$M(n)$ is the number of elements in set S_n,

PR_{sca} is the carrier smoothed and receiver clock adjusted pseudorange correction,

S_n is the set of RRs with valid measurements for satellite n,

S_c is the set of valid ranging sources tracked by all RRs, and

N_c is the number of elements in set S_c;

given the following conditions:

a. If Nc is less than four, a constellation alert shall be generated in accordance with 3.1.5.1.4. If Nc is predicted to be greater than four and more than two ranging sources are determined to be faulted by the LGF, resulting in Nc less than four, an alarm shall be generated in accordance with 3.1.5.1.5.

b. Each RR measurement (*n,m*) used to determine the broadcast corrections shall be updated at no less than a 2 Hz rate.

3.2.1.2.8.5.6.1 Conditions for Broadcast Corrections

The LGF shall cease broadcast of the ranging source measurement block if the magnitude of the pseudorange correction exceeds a threshold. The default value of this threshold shall be field selectable. The LGF shall cease broadcast of the ranging source measurement block unless the pseudorange correction is computed using identical valid navigation data (Sections 3.2.1.2.8.3.1 and 3.2.1.2.8.3.2) decoded from the reference receivers.

3.2.1.2.8.6 Range Rate Correction (RRC)

The Range Rate Correction Field shall indicate the rate of change of the pseudorange correction, defined to be RRC_{corr}, based on the difference between the current and immediately prior averaged corrections as defined in Section 3.2.1.2.8.5.6, but replacing S_c (and related terms) using the set of valid ranging sources tracked by all RRs for both epochs.

3.2.1.2.8.6.1 Condition for Valid RRC

The LGF shall cease broadcast of the ranging source measurement block if the RRC exceeds +/- 3.4 meters per second.

3.2.1.2.8.7 Sigma Pseudorange Ground

The broadcast σ_{pr_gnd} for each ranging source shall account for all equipment and environmental effects, including the received signal power, the local interference environment, and any transient error in smoothing filter output, relative to steady-state, caused by ionospheric divergence. The code-carrier divergence rate can be assumed to be represented by a Normal distribution with zero mean and a standard deviation of 0.018 m/s.

3.2.1.2.8.7.1 GPS Sigma Pseudorange Accuracy

In the standard interference environment defined in appendix D of the LAAS MOPS (RTCA/DO-253A), the accuracy of the LGF shall be such that the broadcast σ_{pr_gnd} satisfies the following inequality:

$$\sigma_{pr\_gnd}(\theta_n) \le \sqrt{\frac{\left(a_0 + a_1 e^{-\theta_n/\theta_0}\right)^2}{M(n)} + (a_2)^2} \qquad (6)$$

where θ_n is the n^th ranging source elevation angle, a_0, a_1, a_2, and θ_0 are the coefficients for the applicable Accuracy Designator defined in Table 3-3.

Table 3-3. GPS Accuracy Designator C Coefficients

Accuracy Designator C	a_0 meters	a_1 meters	a_2 meters	θ_0 degrees
$\theta_n \ge 35°$	0.15	0.84	0.04	15.5
$\theta_n < 35°$	0.24	0	0.04	-

The accuracy requirement shall be met for a satellite at any azimuth or elevation in the reception mask given in Section 3.2.1.2.6.1. The accuracy requirement shall be met at RR Antenna phase-center heights between 10 feet and 50 feet above the base of the antenna mounting platform. The accuracy requirement shall be met at the Reference Receiver Centroid.

Note: In cases of dual antennas, the phase-center height of the higher element shall be used.

3.2.1.2.8.7.2 SBAS Sigma Pseudorange Accuracy

At the minimum signal strength defined in Appendix 2, Section 2.6.5 of FAA-E-2892B and the standard interference environment defined in appendix D of the LAAS MOPS (RTCA/DO-253A), the accuracy of the LGF shall be such that:

$$\sigma_{pr\_gnd} \leq \frac{1.8}{\sqrt{M(n)}} \qquad (7)$$

The accuracy requirement should be met for a satellite at any azimuth or elevation in the reception mask given in Section 3.2.1.2.6.1. The accuracy requirement shall be met at RR Antenna phase-center heights between 10 feet and 50 feet above the base of the antenna mounting platform. The accuracy requirement shall be met at the Reference Receiver Centroid.

Note: In cases of dual antennas, the phase-center height of the higher element shall be used.

3.2.1.2.8.7.3 Condition for Valid Sigma Pseudorange Ground

The LGF shall detect conditions relating to the broadcast Sigma Pseudorange Ground that result in noncompliance with the results in Sections 3.1.2.1 and 3.1.2.2. When the increase in system risk associated with degraded performance is minimal (is no greater than one order of magnitude), but exceeds design tolerances, the LGF shall initiate a service alert. The threshold shall be adjustable, with a default value set to achieve a nominal false alert rate of 1x 10^{-7} per 15-second interval. When the increase in system risk is not minimal, the LGF shall exclude the offending RR or generate an alarm, as appropriate, and the alarm threshold shall be adjustable. A service alert shall be issued when a RR is excluded except when a single RR remains, at which time an alarm shall be issued. Self-recovery shall not be applied in either case. Automatic restart shall not be attempted when an alarm condition exists when system risk is not minimal. The probability of false RR exclusion or alarm shall be less than 1 x 10^{-7} per 15-second interval.

3.2.1.2.8.7.3.1 Sigma Pseudorange Ground Performance Assessment

In detecting the conditions specified in Section 3.2.1.2.8.7.3, the LGF performance shall be computed using the following sets of data: data over one hour and trend of hourly results over one day; data over one day and trend of daily results over one month; data over one month and trend of monthly results over one year, and since initialization. Performance measures shall include mean, sigma, and distribution of B-values per RR. The correlation between RRs shall be assessed with a frequency consistent with the predicted increase in system risk associated with degraded performance.

3.2.1.2.8.8 B-Values

The B-Value Field shall denote the B-value calculated using the equation:

$$B_{PR}(n,m) \equiv PR_{corr}(n) - \frac{1}{M(n)-1} \sum_{\substack{i \in S_n \\ i \neq m}} PR_{sca}(n,i) \tag{8}$$

where $B_{PR}(n,m)$ is the estimate of the error contribution from RR m.

3.2.1.2.8.8.1 Conditions for Broadcast

The LGF shall indicate the reference receiver measurement is invalid in the B_{PR} field for any measurement whose $B_{PR}(n,m)$ exceeds:

$$\frac{K_{B\_PR}\sigma_{pr\_gnd}(\theta_n)}{\sqrt{M(n)-1}} \tag{9}$$

for GPS and SBAS ranging sources.

Where K_{B_PR} is the PR B-value threshold, K_{B_PR} shall:

a. Be configurable, and

b. Have a minimum configurable value of 5 and a maximum configurable value of 6.

3.2.1.3 Type 2 Message – Differential Reference Point

The LGF shall broadcast the Type 2 Message at least once every 20 consecutive frames from each VDB antenna. The LGF shall broadcast the Type 2 Message a maximum of once per frame including transmissions from all VDB antennas.

3.2.1.3.1 Ground Station Installed Receivers

The Ground Station Installed Receivers Field shall denote the number of installed reference receivers stored in LGF NVM.

3.2.1.3.2 Ground Station Accuracy Designator

The Ground Station Accuracy Designator Field shall denote the accuracy designator stored in LGF NVM.

3.2.1.3.3 Continuity and Integrity Designator

The LGF Ground Continuity and Integrity Designator (GCID) Field shall denote the LGF GCID. The LGF GCID value shall be 1 when no alarm exists. The LGF GCID value shall be seven (7) when an alarm exists.

3.2.1.3.4 Local Magnetic Variation

The Local Magnetic Variation Field shall denote the local magnetic variation stored in LGF NVM.

3.2.1.3.5 Sigma Ionosphere

The Sigma Vertical Ionosphere Gradient Field shall denote the value stored in LGF NVM.

3.2.1.3.5.1 Condition for Valid Sigma Ionosphere

The LGF shall detect Ionospheric conditions that result in noncompliance with the requirements in Sections 3.1.2.1 and 3.1.2.2. When the increase in system risk associated with increased ionosphere gradients exceeds design tolerances, the LGF shall exclude the offending ranging source(s) and generate alerts as appropriate. When ionospheric disturbances cannot be isolated to specific ranging sources, and system risk is not minimal (increases by more than one order of magnitude) as a result, the LGF shall generate an alarm. Self-recovery shall be accomplished after ranging source exclusions or alarms are generated once the integrity requirements in Sections 3.1.2.1 and 3.1.2.2 are again met. The probability of a false alarm shall be less than 5×10^{-8} per 15-second interval.

Note: The sigma ionosphere vertical gradient term must be valid for all users within D_{max} from the LGF reference point, as identified in Section 3.1.2.

3.2.1.3.6 Refractivity Index

The Refractivity Index Field shall denote the refractivity index stored in LGF NVM.

3.2.1.3.7 Scale Height

The Scale Height Field shall denote the scale height stored in LGF NVM.

3.2.1.3.8 Refractivity Uncertainty

The Refractivity Uncertainty Field shall denote the refractivity uncertainty stored in LGF NVM.

3.2.1.3.9 Reference Point

3.2.1.3.9.1 Latitude

The Latitude Field shall denote the LGF reference point latitude stored in LGF NVM.

3.2.1.3.9.2 Longitude

The Longitude Field shall denote the LGF reference point longitude stored in LGF NVM.

3.2.1.3.9.3 Reference Point Height

The Reference Point Height Field shall denote the LGF reference point height above the WGS-84 ellipsoid stored in LGF NVM.

3.2.1.3.10 Reference Station Data Selector (RSDS)

The Reference Station Data Selector field shall denote the LGF RSDS stored in LGF NVM.

3.2.1.3.11 Maximum Use Distance (Dmax)

The Maximum Use Distance field shall denote the LGF Maximum Use Distance stored in LGF NVM for any user that complies with RTCA/DO-253A and is located anywhere within 60 miles of the centroid of the reference receivers.

3.2.1.3.12 Ephemeris Fault-Free Missed Detection Parameters

3.2.1.3.12.1 $K_{md\_e\_POS,\ GPS}$

The $K_{md\_e\_POS,\ GPS}$ field shall denote the ephemeris fault-free missed detection parameter for the GPS Differential Positioning Service stored in LGF NVM.

3.2.1.3.12.2 $K_{md\_e\_CAT\ I,\ GPS}$

The $K_{md\_e\_CAT\ I,\ GPS}$ field shall denote the ephemeris fault-free missed detection parameter for the GPS Category I Precision Approach stored in LGF NVM.

3.2.1.3.12.3 $K_{md\_e\_POS,\ GLONASS}$

The $K_{md\_e\_POS,\ GLONASS}$ field shall denote that this parameter is not used.

3.2.1.3.12.4 $K_{md\_e\_CAT\ I,\ GLONASS}$

The $K_{md\_e\_CAT\ I,\ GLONASS}$ field shall denote that this parameter is not used.

3.2.1.4 Type 4 Message – Final Approach Segment Data

The LGF shall broadcast each FAS data block at least once every 20 consecutive frames from each VDB antenna. The LGF shall broadcast each FAS data block a maximum of once per frame including transmissions from all VDB antennas.

3.2.1.4.1 Data Set Length

The Data Set Length Field shall denote the Type 4 Message data set length, which indicates the number of bytes in the data set.

3.2.1.4.2 FAS Data Block

The Type 4 Message shall contain the FAS data block for each runway approach served by the LGF. The following subsections define the required content of the data block. This block and its corresponding approach performance designator are broadcast depending on the runway end(s) selected at the ATCU, and the MDT when necessary.

3.2.1.4.2.1 Operation Type

The Operation Type Field shall denote the operation type stored in LGF NVM.

3.2.1.4.2.2 SBAS Provider Identification

The SBAS Provider ID Field shall denote the SBAS service provider ID stored in LGF NVM.

3.2.1.4.2.3 Airport Identification

The Airport Identification Field shall denote the airport identification stored in LGF NVM.

3.2.1.4.2.4 Runway Number

The Runway Number Field shall denote the runway number stored in LGF NVM.

3.2.1.4.2.5 Runway Letter

The Runway Letter Field shall denote the runway letter stored in LGF NVM.

3.2.1.4.2.6 Approach Performance Designator

The Approach Performance Designator Field shall denote the approach category stored in LGF NVM.

3.2.1.4.2.7 Route Indicator

The Route Indicator Field shall denote the route indicator stored in the LGF NVM.

3.2.1.4.2.8 Reference Path Data Selector

The Reference Path Data Selector Field shall denote the reference path data selector stored in LGF NVM.

3.2.1.4.2.9 Reference Path Identifier

The Reference Path Identifier Field shall denote the reference path identifier stored in LGF NVM.

3.2.1.4.2.10 LTP/FTP Latitude

The LTP/FTP Latitude Field shall denote the LTP/FTP latitude stored in LGF NVM.

3.2.1.4.2.11 LTP/FTP Longitude

The LTP/FTP Longitude Field shall denote the LTP/FTP longitude stored in LGF NVM.

3.2.1.4.2.12 LTP/FTP Height

The LTP/FTP Height Field shall denote the LTP/FTP height stored in LGF NVM.

3.2.1.4.2.13 Delta FPAP Latitude

The Δ FPAP Latitude Field shall denote the Δ FPAP latitude stored in LGF NVM.

3.2.1.4.2.14 Delta FPAP Longitude

The Δ FPAP Longitude Field shall denote the Δ FPAP longitude stored in LGF NVM.

3.2.1.4.2.15 Approach Threshold Crossing Height

The Approach Threshold Crossing Height (TCH) Field shall denote the TCH stored in LGF NVM.

3.2.1.4.2.16 Approach TCH Units Selector

The TCH Units Selector Field shall denote the TCH Unit Selector stored in LGF NVM.

3.2.1.4.2.17 Glidepath Angle

The Glidepath Angle (GPA) Field shall denote the GPA stored in LGF NVM.

3.2.1.4.2.18 Course Width

The Course Width Field shall denote the course width stored in LGF NVM.

3.2.1.4.2.19 Delta Length Offset

The Δ Length Offset Field shall denote the Δ length offset stored in LGF NVM.

3.2.1.4.2.20 FAS CRC

The FAS CRC Field shall denote the FAS CRC stored in LGF NVM.

3.2.1.4.3 FAS VAL/Approach Status

The FAS VAL/Approach Status Field shall denote the FAS VAL stored in the LGF NVM, or "Do Not Use Vertical" when selected in accordance with Sections 3.3.2.3 or 3.3.2.2.15.

3.2.1.4.4 FAS LAL/Approach Status

The FAS LAL/Approach Status Field shall denote the FAS LAL stored in the LGF NVM, or "Do Not Use Approach" when selected in accordance with Section 3.3.2.2.15.

3.2.2 RADIO FREQUENCY TRANSMISSION CHARACTERISTICS

3.2.2.1 Symbol Rate

The symbol rate of the LGF data broadcast shall be 10,500 ±0.005% symbols per second. Each symbol defines one of eight states (3 bits) resulting in a nominal bit rate of 31,500 bits per second.

3.2.2.2 Emission Designator

The emission designator of this modulation technique is 14K0G7DET.

3.2.2.3 Signal Polarization

The LGF shall be able to broadcast either an elliptically polarized (EPOL) signal or a horizontally polarized (HPOL) signal. The option to transmit either an EPOL or HPOL signal shall be selected by changing only the antenna and power setting.

3.2.2.4 Field Strength

3.2.2.4.1 Horizontal Field Strength

The minimum field strength shall not be less than 215 μV/m (-99 dBW/m^2) for a horizontally polarized signal. The maximum field strength shall not be greater than 350 mV/m (-35 dBW/ m^2) for a horizontally polarized signal.

3.2.2.4.2 Vertical Field Strength

The minimum field strength shall not be less than 136 μV/m (-103 dBW/ m^2) for the vertically polarized signal. The maximum field strength shall not be greater than 221 mV/m (-39 dBW/ m^2) for the vertically polarized signal.

3.2.2.5 Spectral Characteristics

3.2.2.5.1 Carrier Frequencies

The VDB shall use radio frequencies in the band 108 – 117.975 MHz. The lowest selectable channel shall be 108.025 MHz. The highest selectable channel shall be 117.950 MHz. The separation between selectable frequencies shall be 25 kHz.

3.2.2.5.2 Unwanted Emissions

Unwanted emissions, including spurious and out-of-band emissions, shall be compliant with the levels shown in Table 3-4. The total power in any VDB harmonic or discrete signal shall be no greater than -53 dBm.

Table 3-4. Unwanted Emission Levels

Frequency	Relative Unwanted Emission Level [2]	Maximum Unwanted Emission Level [1]
9 kHz to 150 kHz	-93 dBc [3]	-55 dBm/1kHz [3]
150 kHz to 30 MHz	-103 dBc [3]	-55 dBm/10 kHz
30 MHz to 106.125 MHz	-115 dBc	-57 dBm/100 kHz
106.425 MHz	-113 dBc	-55 dBm/100 kHz
107.225 MHz	-105 dBc	-47 dBm/100 kHz
107.625 MHz	-101.5 dBc	-53.5 dBm/10 kHz
107.825 MHz	-88.5 dBc	-40.5 dBm/10 kHz
107.925 MHz	-74 dBc	-36 dBm/1 kHz
107.9625 MHz	-71 dBc	-33 dBm/1 kHz
107.975 MHz	-65 dBc	-27 dBm/1 kHz
118.000 MHz	-65 dBc	-27 dBm/1 kHz
118.0125 MHz	-71 dBc	-33 dBm/1kHz
118.050 MHz	-74 dBc	-36 dBm/1 kHz
118.150 MHz	-88.5 dBc	-40.5 dBm/10 kHz
118.350 MHz	-101.5 dBc	-53.5 dBm/10 kHz
118.750 MHz	-105 dBc	-47 dBm/100 kHz
119.550 MHz	-113 dBc	-55 dBm/100 kHz
119.850 MHz to 1 GHz	-115 dBc	-57 dBm/100 kHz
1 GHz to 1.7 GHz	-115 dBc	-47 dBm/1MHz

Note 1: The maximum unwanted emission level (absolute power) applies if the authorized transmitter power exceeds 150 W.

Note 2: The relative unwanted emission level is to be computed using the same bandwidth for desired and unwanted signals. This may require conversion of the measurement for unwanted signals done using the bandwidth indicated in the maximum unwanted emission level column of Table 3-4.

Note 3: This value is driven by measurement limitations. Actual performance is expected to be better.

Note 4: The relationship is linear between single adjacent points designated by the adjacent channels identified in Table 3-4.

3.2.2.6 Adjacent Channel Emissions

The amount of power during transmission, under all operating conditions, when measured over a 25 kHz bandwidth centered on any adjacent channel, shall not exceed the values given in Table 3-5:

Table 3-5. Adjacent Channel Emissions

Channel	Relative Power	Maximum Power
1st Adjacent	-40 dBc	12 dBm
2nd Adjacent	-65 dBc	-13 dBm
4thAdjacent	-74 dBc	-22 dBm
8th Adjacent	-88.5 dBc	-36.5 dBm
16th Adjacent	-101.5 dBc	-49.5 dBm
32nd Adjacent	-105 dBc	-53 dBm
64th Adjacent	-113 dBc	-61 dBm
76th Adjacent and beyond	-115 dBc	-63 dBm

Note 1: The maximum power applies if the authorized transmitter power exceeds 150 W.

Note 2: The relationship is linear between single adjacent points designated by the adjacent channels identified in Table 3-5.

3.2.2.6.1 Adjacent Temporal Interference

Under all operating conditions, the maximum power over a 25 kHz bandwidth, centered on the assigned frequency, when measured over any unassigned time slot, shall not exceed -105 dBc referenced to the authorized transmitter power.

3.2.2.6.2 Frequency Stability

The long-term stability of the transmitter carrier frequency shall be ± 0.0002%.

3.2.2.7 Modulation

Binary data shall be assembled into symbols, each consisting of three consecutive bits. The end of the data shall be padded by up to two fill bits if necessary to form the last 3-bit symbol of the burst. Symbols shall be converted to differentially encoded 8-phase shift keyed (D8PSK) carrier phase shifts ($\Delta\phi_k$) as shown in Table 3-6.

The carrier phase for the kth symbol (ϕ_k) is given by:

$$\phi_k = \phi_{k-1} + \Delta\phi_k. \tag{10}$$

The transmitted signal shall be:

$$H(e^{j(2\pi ft + \phi(t))}) \tag{11}$$

where H(•) is a raised cosine filter with α=0.6 as defined in Section 3.2.2.7.1.

Table 3-6. Data Encoding

Message Bits (note)			**Symbol Phase Shift**
$\mathbf{I_{3k-2}}$	$\mathbf{I_{3k-1}}$	$\mathbf{I_{3k}}$	$\mathbf{\Delta\phi_k}$
0	0	0	0
0	0	1	1π/4
0	1	1	2π/4
0	1	0	3π/4
1	1	0	4π/4
1	1	1	5π/4
1	0	1	6π/4
1	0	0	7π/4

Note: I_j is the j^{th} bit of the burst to be transmitted, where I_1 is the first bit of the training sequence. The values of $\Delta\phi_k$ represent counter clockwise rotations in the complex I-Q plane of Figure 2-1 of RTCA/DO-246B.

3.2.2.7.1 Pulse Shaping Filters

The output of differential phase encoder shall be filtered by a pulse shaping filter whose output, s(t), is:

$$s(t) = \sum_{k=-\infty}^{k=\infty} e^{j\phi_k} h(t - kT) \qquad (12)$$

where h = the impulse response of the raised cosine filter

t = time

T = duration of each symbol (T=1/10500 second, approximately 95.2 μsec), and

ϕ_k = as defined in Section 3.2.2.7.

This pulse shaping filter shall have a nominal complex frequency response of a raised-cosine filter with $\alpha = 0.6$. The frequency response, *H(f),* and the time response, *h(t),* of the base band filters shall be in accordance with

$$H(f) = \begin{cases} 1 & 0 < f < \dfrac{1-\alpha}{2\mathrm{T}} \\[2ex] \dfrac{1 - \sin\left(\dfrac{\pi}{2\alpha}(2f\mathrm{T} - 1)\right)}{2}, & \dfrac{1-\alpha}{2\mathrm{T}} \le f \le \dfrac{1+\alpha}{2\mathrm{T}} \\[2ex] 0 & f > \dfrac{1+\alpha}{2\mathrm{T}} \end{cases} \qquad (13)$$

$$h(t) = \frac{\sin\left(\dfrac{\pi t}{T}\right)\cos\dfrac{\pi\alpha t}{T}}{\dfrac{\pi t}{T}\left[1 - \left(\dfrac{2\alpha t}{T}\right)^2\right]} \qquad (14)$$

where f is the absolute value of the frequency offset from the channel center,

T is the symbol period of 1/10500 seconds (approximately 95.2 μ seconds),

t is time, and

α is 0.6.

3.2.2.7.2 Error Vector Magnitude

The error vector magnitude of the transmitted signal shall be less than 6.5% RMS.

3.2.2.8 Burst Data Content

Burst Data Content shall comply with Section 2.3 of RTCA/DO-246B.

3.2.2.9 Broadcast Timing Structure Division Multiple Access

The broadcast timing structure shall comply with Section 2.2 of RTCA/DO-246B. The LGF shall be capable of transmitting in any two of eight time slots within each frame from each VDB antenna. In every frame, the LGF shall broadcast a message in every slot designated in LGF NVM.

3.2.3 RADIO FREQUENCY BROADCAST MONITORING

The data broadcast transmissions from each VDB antenna shall be monitored. The transmission of the data from a single VDB antenna shall cease within 0.5 seconds when any of the following conditions exist:

a. Continuous disagreement for any 3 second period between the transmitted application data and the application data derived or stored by the monitoring system prior to transmission,

b. A transmitted power reduction of more than 3 dB from the on-channel assigned power for 3 seconds,

c. A transmitted power increase of more than 3 dB from the on-channel assigned power for 1 second. The probability that the transmitted power is increased more than 3 dB for 1 second shall be less than 2.0 x 10^{-7} in any 30-second period,

d. More than 0.2% of messages in the last hour are not transmitted,

e. No transmission for 3 seconds, or

f. Any transmitted data outside of the assigned TDMA time slots for 1 second in excess of the limit defined in 3.2.2.6.1. The risk that the LGF transmits a signal in an unassigned slot and fails to detect an out-of-slot transmission, within 1 second, shall be less than 1.0 x 10^{-7} in any 30-second period.

Conditions (a) through (f) include the time to switch to redundant equipment, if available.

3.3 OPERATION AND MAINTENANCE

Operations and maintenance functions are provided via internal and external LGF components. These components include:

a. LSP (internal),

b. MDT (internal),

c. ATCU (external),

d. LGF Built-in-Test (BIT) (internal),

e. Recording (internal, Sections 3.3.3.1 and 3.3.3.2), and

f. Recording (external, Sections 3.3.3.2 and 3.3.3.3).

Figure 3-4 provides a high-level diagram depicting the functional relationship between the LGF and Operations and Maintenance.

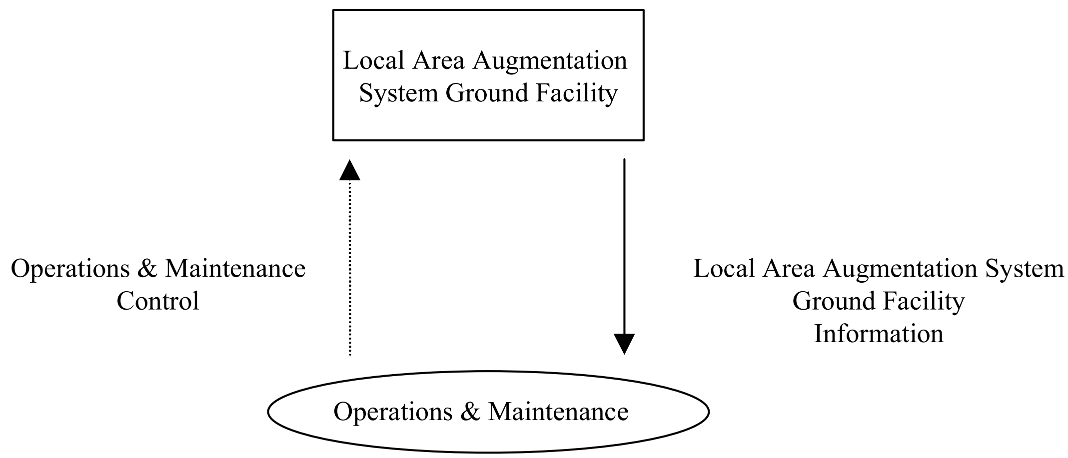


Figure 3-4. Operations and Maintenance

Figure 3-5 depicts the internal and external interfaces of the LGF.

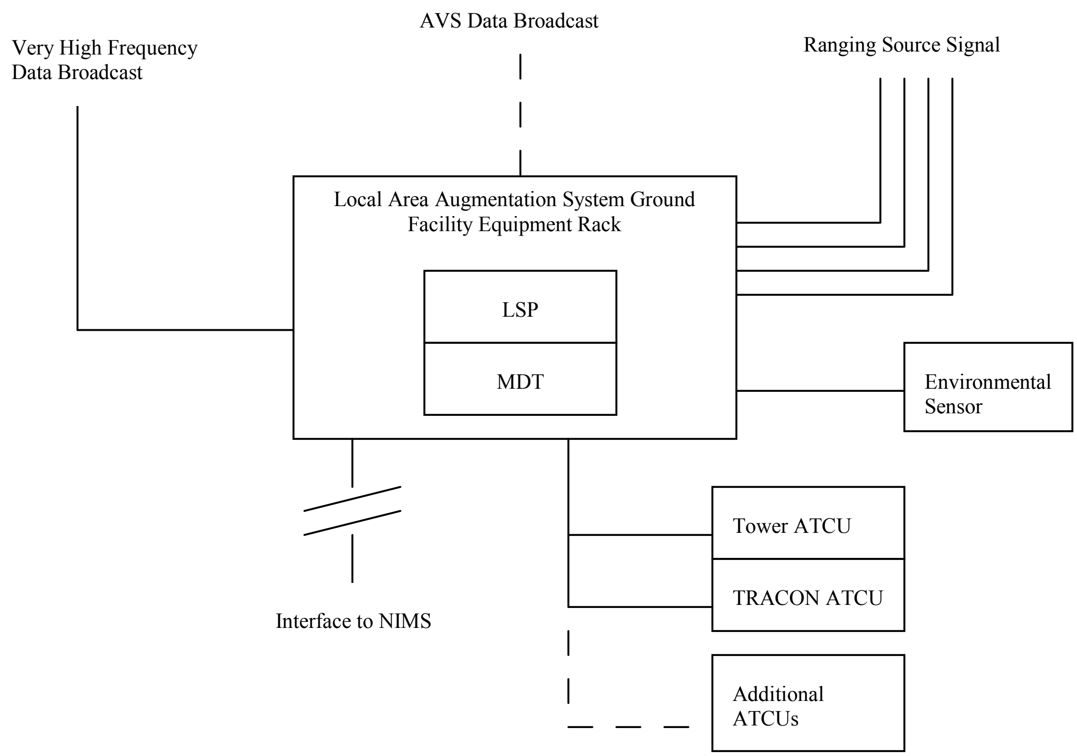


Figure 3-5. Local Area Augmentation System Ground Facility Interfaces

3.3.1 SYSTEM REQUIREMENTS

3.3.1.1 LGF Configuration

3.3.1.1.1 Standard LGF Equipment Configuration

The LGF shall be configured such that:

a. Each RR is collocated with the RR-antenna.

b. There are four (4) RR/RR-antenna pairs.

c. The primary VDB electronic equipment, including transmitter, monitor, and power amplifier, are fully redundant; and, both sets of equipment are housed in the primary equipment shelter and share a common EPOL antenna.

d. The LGF correction processors, integrity monitor processors, power supplies, back-up power source, LSP, and all other equipment are housed in the primary equipment shelter.

e. Equipment listed in (c) and (d) fits in standard 19 in. racks.

f. There are two (2) ATCUs.

g. There is one (1) MDT attached to the LGF equipment rack.

3.3.1.1.2 Additional VDB Subsystems

The LGF shall have interfaces to support up to three (3) Additional VDB Subsystems (AVS).

3.3.1.1.2.1 AVS Configuration Capability

The AVS shall be capable of being configured to work with:

a. Standard EPOL antenna meeting coverage volume in Section 3.1.1.1.1 and Field Strength in Section 3.2.2.4.

b. Standard HPOL antenna meeting coverage volume in Section 3.1.1.1.1 and Field Strength in Section 3.2.2.4.1 .

3.3.1.1.2.2 AVS Equipment

The AVS electronic equipment shall be identical to the Primary VDB Subsystem hardware. Each AVS shall:

a. Be capable of independent remote operation at a distance of up to 5 nm from the Primary VDB Subsystem, and

b. Continue to operate if the primary VDB electronic equipment is removed or becomes non-functional.

3.3.1.1.3 LGF Subsystem Installation Requirements

3.3.1.1.3.1 Reference Receiver/Primary Equipment Shelter

The reference receiver (RR) and RR-antenna shall be co-located at a distance up to 5 nm from the primary equipment shelter.

3.3.1.1.3.2 Primary VDB Antenna/Primary Equipment Shelter

The primary VDB antenna and the VDB transmitter located in the primary equipment shelter shall be connected via an RF interface up to a distance of 1000 ft.

3.3.1.2 Computer Resources

3.3.1.2.1 Computer Memory

The LGF shall incorporate error sensing, error reporting, and error correction to all memory processors and component hardware.

3.3.1.2.2 Non-Volatile Memory (NVM)

NVM Storage shall be a minimum of 90 days without power applied.

3.3.1.2.3 Reserve Capacity

3.3.1.2.3.1 Volatile Memory

At delivery, no more than 50% of the total addressable, populated memory locations per processor shall be used during execution of any program to hold instructions or data.

3.3.1.2.3.2 Processing Speed

At delivery, each processor, including input/output subsystems, in the LGF System that executes software in support of system performance requirements shall use a maximum of 70% of the processor's throughput capability.

3.3.1.3 Primary Power

The LGF shall operate from a nominal 120 volt, 60 Hz, three wire, single-phase AC power source.

3.3.1.4 Supplementary Power

The LGF shall include an uninterruptible supplementary power source. The supplementary power source shall continuously power the LGF for a period of not less than four hours after a loss of primary power under nominal conditions. Nominal conditions are defined to be a room temperature of 30° C and a Voltage Standing Wave Ratio (VSWR) of 1.5:1. The LGF shall provide status and health data for the supplementary power.

3.3.1.4.1 Power Supply

The LGF shall automatically sense when the supplementary power discharge point is reached. When operating on supplementary power, the LGF shall initiate facility shutdown if a critical discharge point is met. Upon restoration of primary power, the LGF shall self-restore to operate on primary power. To maintain the supplementary power in operational readiness, a trickle charge shall be supplied to recharge the supplementary power during the period of available primary power. Upon loss and subsequent restoration of primary power, the LGF supplementary power shall restore to a full charge condition from a 50% discharge condition within 8 hours. The LGF shall continue at the same level of service upon restoration of primary power.

3.3.1.5 Environmental Sensors

The LGF design shall include an:

a. Intrusion detector sensor,
b. Smoke detector sensor,
c. Obstruction lights sensor,
d. AC power sensor,
e. Inside temperature sensor, and
f. Outside temperature sensor.

The environmental sensor output shall be processed by the LGF and retrievable by the MDT. The LGF shall be capable of bypassing any sensor that is not used.

3.3.1.5.1 Intrusion Detector

The intrusion detector shall detect when the LGF shelter door has been open for any period greater than 0.50 seconds. The LGF shall generate a service alert message if valid log-on ID and password entries are not received within 5 minutes of detecting an open shelter door. Upon command, the LGF shall arm and bypass the intrusion detector through the MDT.

3.3.1.5.2 Smoke Detector

The smoke detector shall be an ionization-type smoke detector. The smoke detector shall meet the requirements of Underwriters Laboratories (UL), Inc. Standard 268. The smoke detector shall bear the UL, Inc. label. The LGF shall generate a service alert upon detection of combustion products.

3.3.1.5.3 Obstruction Lights

The LGF shall identify when a lamp has failed in the obstruction light assembly of the antennas. The LGF shall generate an alert message when a lamp fails.

3.3.1.5.4 AC Power

The AC power sensor shall detect the presence of primary AC power. The LGF shall generate a service alert when a loss of AC power is detected. The LGF shall generate a service alert when the AC power sensor detects the absence of acceptable primary AC power.

3.3.1.5.5 Inside Temperature

The inside temperature sensor shall provide the temperature inside the LGF equipment shelter to the LGF, with a minimum resolution of one-degree centigrade. The accuracy over the range of -10º to +50º centigrade shall be ± 5º centigrade without calibration. The LGF shall generate an alert when the temperature has exceeded the alert thresholds. The LGF shall generate a service alert message when the upper and lower temperature design thresholds are exceeded.

3.3.1.5.6 Outside Temperature

The outside temperature sensor shall provide the temperature outside the LGF equipment shelter to the LGF with a minimum resolution of no less than one-degree centigrade. The accuracy over the range of -50° to +70° centigrade shall be ± 5° centigrade without calibration.

3.3.1.6 Fault Diagnostics, Built-in-Test, and Isolation Procedures

The LGF shall perform automatic and manually initiated fault diagnosis to the LRU level. The resulting data shall be stored in memory until manually cleared via the MDT. Stored data shall be accessible via the MDT. Manually initiated diagnostics shall be available from the MDT. A combination of fault diagnostics, BIT, BITE, and manual isolation shall enable the following:

a. Automatically initiating the diagnostic routine when an alarm occurs,

b. Automatic diagnostic fault isolation rates at 90% or greater to an ambiguity group of three LRUs or less, and

c. Manual isolation to a single LRU 100% of the time.

3.3.1.7 Reliability, Maintainability, and Availability of LGF Equipment

3.3.1.7.1 Maintenance Concept

The LGF shall provide for a site and depot concept of maintenance. This concept assumes the use of modular equipment that enables maintenance specialists to correct a majority of equipment failures on-site by replacing the faulty LRU.

3.3.1.7.2 Reliability

The Mean Time Between Failures (MTBF) for the LGF shall be at least 2190 hours. A failure resulting in a service alert as defined in Section 3.1.5.1.3.1, or an alarm as defined in Section 3.1.5.1.5, shall contribute to the MTBF.

3.3.1.7.3 Maintainability

3.3.1.7.3.1 Mean Time To Repair (MTTR)

The Mean-Time-to-Repair (MTTR) shall be less than 30 minutes. The repair time shall include:

a. Diagnostic time,

b. Removal of the failed LRU,

c. Installation of the new LRU,

d. Initialization of the new LRU, and

e. All adjustments required to return the LGF to the Normal Mode.

3.3.1.7.3.2 Periodic Maintenance

Periodic maintenance for the LGF shall not interrupt service for more than 8 hours per year of operation. No single group of periodic procedures shall be required more frequently than every 2190 hours. Periodic maintenance for the ATCU shall not exceed 1 hour in 4380 hours of operation. Periodic maintenance shall include the time required to complete the routine checks and inspections necessary to assure normal operation.

Upon command, the MDT shall isolate latent faults affecting integrity and continuity utilizing embedded equipment, software, or special test equipment.

3.3.1.7.4 Availability

The standard equipment configuration defined in Section 3.3.1.1.1 shall have a mean time between critical failures (MTBCF) of at least 7,200 hours and an inherent availability, of 0.99993. Inherent availability is defined as the probability that the LGF is operating at any instant in time. A critical failure shall be defined as any failure resulting in an alarm condition as defined in Section 3.1.5.1.5. This assumes an ideal support environment, with the MTTR as specified in Section 3.3.1.7.3.1, the MTBF as specified in Section 3.3.1.7.2, and zero response time.

3.3.1.7.5 System Specialist Workload

Completion of corrective and periodic maintenance actions shall require no more than two (2) system specialists.

3.3.1.8 Security

3.3.1.8.1 Access Control

3.3.1.8.1.1 Identification and Authentication

3.3.1.8.1.1.1 User Identifier and Authentication Management

The System Administrator shall provide security management for system access. The Administrator shall have sole rights and access to add, delete, and change user identifiers and initial passwords via an MDT. Upon completion of editing changes or adding or deleting a user identifier data, the Administrator shall be prompted for confirmation of the Administrator's password. All identifier or password changes shall be updated automatically and immediately in the user identifier and password file.

3.3.1.8.1.1.2 User Identification and Authentication

Each user shall be identified by a unique identifier and password.

3.3.1.8.1.1.3 Number of Users

The LGF shall accommodate a minimum of 24 users.

3.3.1.8.1.2 Access Management

3.3.1.8.1.2.1 Access Authorization

Only users authorized by the System Administrator shall have access to the LGF components. All users shall logon at their authorized access level (Section 3.3.1.8.1.2.2.2).

3.3.1.8.1.2.1.1 Invalid Access Attempt

An invalid logon entry shall cause:

a. An "Invalid User ID or Password" error message to be displayed,

b. 'Denial of access' for a default period of 15 minutes after three (3) invalid entries, and

c. Generation of an alert for each invalid access attempt.

3.3.1.8.1.2.1.2 Denial of Access

The system shall generate an alert (Section 3.1.5.1.2) upon detection of 'denial of access' events at each user interface.

3.3.1.8.1.2.2 Identifier Access Characteristics

3.3.1.8.1.2.2.1 Session Duration

The System Administrator shall assign a session idle time for each user based on access level and operational function. Maintenance Specialists shall be able to adjust their own session duration per session.

3.3.1.8.1.2.2.1.1 Inactive User Sessions

The system shall automatically logout any user session inactive for more than its assigned session idle time. Forced logouts of inactive user sessions shall generate an alert for a nominal time of 5 minutes prior to logout.

3.3.1.8.1.2.2.2 Access Levels

Logical user access levels shall consist of the following:

a. Access Level 1: General Use/System Monitoring (NIMS) – Read Only,

b. Access Level 2: ATCU Specialist – Modify runway operational parameters,

c. Access Level 3: Remote Certified Maintenance Specialist – Modify configuration parameters,

d. Access Level 4: Local Certified Maintenance Specialist – Modify operational states and modes, modify runway operational parameters, and

e. Access Level 5: System Administrator – Add, Change, Delete User ID, Password, and Access Level; Audit Log File Processes.

3.3.1.8.1.2.2.3 User Access Constraints

The System Administrator shall assign user identifier access constraints as appropriate for time-of-day and port-of-entry.

3.3.1.8.1.2.2.4 User Access Rights

The System Administrator shall assign user access rights (read, write, execute) to data objects as appropriate.

3.3.1.8.1.2.2.4.1 Read Access

Upon command, an MDT shall read LGF internally stored data and diagnostic information.

3.3.1.8.1.2.2.4.2 Write Access

Upon command, an MDT shall load FAS data, input site-specific parameters, and all other maintenance actions in accordance with Sections 3.3.1.8.1.2.2.4.3 and 3.3.1.9.1.2.2.4.4.

3.3.1.8.1.2.2.4.3 Write Access - MDT

The MDT shall have write access while in Test Mode, Normal Mode, and Not Available Mode.

3.3.1.8.1.2.2.5 User Identifier Duration

User identifiers shall be suspended after a period of time set by the System Administrator ranging from a minimum of one day to infinity.

3.3.1.8.1.2.2.5.1 User Identifier Suspension

User identifier shall be suspended after a default of three (3) failed logon attempts, or a number set by the System Administrator up to a maximum of 10.

3.3.1.8.1.2.2.6 User Password Duration

The LGF shall prompt users to change passwords every 90 days. Password life shall be configurable up to a maximum of 365 days by the System Administrator. The LGF shall not allow the reuse of passwords during 12 consecutive password changes. The System Administrator shall be able to force the changing of all user passwords on an ad hoc basis.

3.3.1.8.1.3 Password Management

3.3.1.8.1.3.1 Password Characteristics

The LGF shall allow passwords to contain upper and lower case letters, numbers and special characters. Password length shall be adaptable up to 16 characters and will be based on local operational procedures.

3.3.1.8.1.3.2 Password Distribution

The System Administrator distributes the user identifier and initial password to an authenticated user. User identifiers and passwords shall be stored in a protected file and in an encrypted format if maintained on the LGF. The password file shall be accessible only to the System Administrator.

3.3.1.8.1.3.3 User Password Changes

A user shall be able to change their password. The user shall be prompted to change their password after the first logon and at every subsequent expiration of their identifier's password life. All password changes shall be confirmed by a password confirmation prompt before acceptance by the system. The LGF shall display user identifiers on the logon terminal, and password display shall be obscured.

3.3.1.8.2 Network and Data Communications

All network and data communications shall be secured based on the technical requirements for each interface.

a. Intra LGF and LSP interfaces: The vendor shall design all intra LGF interfaces to assure that the LGF and LSP (Section 3.3.4.1) are secured from unauthorized access.

b. LGF to NIMS Interface: The NIMS interface (Section 3.3.4.4) shall conform to NAS-IR-51070000 (3.3.2.5.3).

3.3.1.8.3 Security Management

3.3.1.8.3.1 System Identification

The LGF shall display a warning banner to each user before logon. The warning banner shall be stored in NVM and shall only be accessible to the Systems Administrator for maintenance purposes.

3.3.1.8.3.2 Software Protection

Lookup tables, routing tables, user profile directories, audit log files or other files associated with controlling security access or services shall not be accessible to user application processes, or system resources operated under user control. Separate control systems, unique to the management of security services shall be created for the sole use of the security management function.

The internal and external LGF components shall protect stored data and information transfer from unauthorized access. Current technological best practices shall be used throughout the design and development phases.

3.3.1.8.4 Accountability and Traceability

3.3.1.8.4.1 Audit Log File Recording

The system shall have an audit log file as part of the system events recording function (Section 3.3.3.1). The log file shall only be written to by the secure portion of the operating system and shall be protected against deletion and modification. All system administration functions and security-relevant activities, including logon and logoff, and user identifier and authentication maintenance, performed by any user, both successful and unsuccessful, shall be logged in the audit log file. The logged data shall include user identifier, timestamp and other data as necessary to support individual accountability and detection and response to insecurity.

3.3.1.8.4.2 Audit Log File Maintenance

The audit log file shall be developed in such a way that data analysis and reduction may be performed by the System Administrator through a commercially available software tool. The System Administrator shall only be able to delete the log file after a successful archival procedure.

3.3.1.8.4.3 Audit Log File Archive

The system shall allow for the System Administrator to specify the period of time between audit log file archiving. The audit log file archiving process shall provide for unattended logging for a period of up to 90 days. The system shall maintain audit log files for a period of 90 days.

3.3.1.9 Physical Design for Certification

The LGF and the status and control subsystem-component equipment shall facilitate the accomplishment of all maintenance and certification procedures through the physical design of the equipment.

3.3.1.9.1 System Verification Requirements

The LGF shall be designed in such a manner so that the system performance can be checked and verified for proper operation, by a qualified (certified) Airway Facilities specialist, prior to commissioning, at specific periodic intervals, after system repairs, and at other times as needed.

3.3.1.9.1.1 Key Performance Parameters

Key performance parameters shall be identified for periodic maintenance, corrective maintenance, and integrity monitoring functions. "A key performance parameter is a selected parameter of the system, subsystem, or equipment, which is a critical indicator of whether or not it is performing its intended function." (FAA Order 6000.15) Key performance parameters of the LGF shall be capable of independent verification during system performance checks. Independent verification shall be facilitated through the use of test equipment and procedures, to include Built-in-Test (BIT) and Built-in-Test-Equipment (BITE), as appropriate. BITE shall be capable of independent verification.

3.3.1.9.1.2 Executive Monitor Key Performance Parameters

Executive monitor key performance parameters are system characteristics, whose variance outside specified limits requires automatic equipment action. The executive monitoring action shall be capable of independent verification through the presence of a fault condition that stimulates the executive monitor action.

3.3.1.9.2 VDB Transmitter Key Performance Parameter

The VDB Transmitter key performance parameter verification requirements shall include:

a. Frequency stability within the tolerance specified in Section 3.2.2.6.2 (while transmitting into a dummy load),

b. Spectral characteristics (for example, first harmonic to assure proper transmit filter mask, into a dummy load),

c. Time Slot tolerance, given in Section 3.2.2.6.1 (while transmitting into a dummy load),

d. Absolute Power, within 3 dBm, of assigned power (measured at the input to the antenna),

e. VSWR (measured at the input to the antenna), and

f. Section 3.2.3 (a) through (f), (verify as appropriate).

3.3.1.9.3 Monitor Key Performance Parameters

The Monitor key performance parameters and executive monitor action verification shall include:

a. RF level alarm. Reduce RF level to alarm point and ensure an alarm occurs, per Sections 3.2.3(b) and 3.1.5.1.5,

b. VDB monitor bit check. Detect a disagreement between the data that is intended to be transmitted and the data that is detected after transmission, and terminate VDB output if disagreement, and generate an alarm per Sections 3.2.3(a) and 3.1.5.1.5,

c. An end-to-end verification of functional failure paths from RR antennas to the input signal of the VDB transmitter, with an observable executive monitor action. An example of this type of test may be software added pad to pseudorange measurements, resulting in a B-value measurement fault on any single reference receiver path,

d. Built-in-test (BIT) and Built-in-test-equipment (BITE), per Section 3.3.1.6, as appropriate, and

e. Monitored parameters and executive actions identified in Section 3.1.5, Executive Monitoring, and table 3-1, as appropriate.

3.3.1.10 Electronic Equipment, General Requirements

The LGF shall meet the general navigational aid equipment requirements of this section and Table 3-7, tailored from FAA-G-2100G, “Electronic Equipment, General Requirements,” dated October 22, 2001.

Table 3-7. General Navigational Aid Electronic Equipment Requirements

Requirement	FAA-G-2100G Section	Applicability Notes
REQUIREMENTS	3	
General	3.1	
Electrical Power	3.1.1	Applies in total
Mechanical	3.1.2	Applies in total
Software	3.1.3	See section 3.1.6 *Software Design Assurance* of this specification and FAA-STD-026 DIDs and CDRLs in SOW
Characteristics	3.2	
Environmental Conditions	3.2.1	Applies with additional clarification in Section 3.3.1.10.1 and Table 3-8 of this specification
Physical Characteristics	3.2.2	Applies in total
Reliability	3.2.3	Applies except where specified in sections 3.3.1.7.2 and 3.3.1.7.4 of this specification
Maintainability	3.2.4	Maintainability requirements in sections 3.3.1.7.1, 3.3.1.7.3, and 3.3.1.7.5 of this specification. Additional requirements of section 3.2.4 of FAA-G-2100G and section 3.3.1.10.6 of this specification apply.
[Failsafe] External Equipment Interfaces	3.2.5	Applies in total
Electrostatic Discharge	3.2.6	Applies in total
Transportability	3.2.7	Transportability requirements in section 3.3.1.10.2 of this specification.
Equipment Design and Construction	3.3	
Materials, Processes and Parts	3.3.1	Applies in total. Additional materials design constraints are in section 3.3.1.10.3 of this specification.
Electromagnetic Compatibility (EMI/EMC) and FCC Type Certification	3.3.2	Applies in total. Additional requirements for FCC Type Certification of Radio navigational aid transmitters in accordance with Part 87 (47 CFR 87) specified in section 3.3.1.10.4 of this specification.
Nameplates and Marking	3.3.3	Applies in total.
Interchangeability	3.3.4	Applies in total.
Personal Safety and Health	3.3.5	Applies in total. Additional requirement for Warning and Caution labels are specified in section 3.3.1.10.7 of this section.

Requirement	FAA-G-2100G Section	Applicability Notes
Human Factors Engineering	3.3.6	Applies in total.
Documentation, Personnel and Training	3.4 & 3.5	Applies in total as stated in the Statement of Work
Quality Assurance	4	
Quality Assurance – Quality System Requirements	4.1	Applies in total as stated in the Statement of Work
Quality Assurance – Verification/Compliance to Requirements	4.2	Applies in Total except as modified for sections 4.2.2.2 and 4.2.2.4 and the Statement of Work.
Environmental Stress Screening (ESS)	4.2.2.2	Substitution of Environmental Stress Screening is strongly recommended for Type Testing in section 4.2.2.2, especially when the design includes extensive integration of COTS LRUs.
FCC Type Acceptance and Registration	4.2.2.4	FCC Type Certification and Registration is modified per section 3.3.1.10.5 of this specification.

3.3.1.10.1 Operating Environmental Conditions

The LGF shall meet the requirements of Section 3.2.1 of FAA-G-2100G for operating environment conditions with the following clarifications. LGF equipment designed for use in attended facilities (air traffic control tower cab or equipment room) shall operate in the ambient conditions of Environment I in Table 3-8. LGF equipment designed for use in unmanned facilities (equipment shelter) shall operate with the ambient conditions of Environment II listed in Table 3-7. LGF equipment not housed in shelters shall operate in the ambient conditions of Environment III listed in Table 3-7.

Table 3-8. Environmental Conditions

Environment[1]	Temperature (°C)	Relative Humidity[3] (%)	Altitude (ft above sea level)	Wind (mph)	Ice Loading	Rain
I	+10 to +50	10 to 80	0 to 10,000	--	--	--
II	-10 to +50	5 to 90	0 to 10,000	--	--	--
III[4]	-50 to +70[2]	5 to 100	0 to 10,000	0 to 100	Encased in ½"radial thickness clear ice	2" / hour

1. I: For equipment installed in an attended facility.
II: For equipment installed in an unattended facility.
III: For equipment installed outdoors (antennas, field detectors)
2. Includes 18°C for solar radiation.
3. Above 40°C, the relative humidity shall be based upon a dew point of 40°C.
4. Conformal coating is required only when equipment is exposed to salt atmosphere or located in tropical climates.

3.3.1.10.2 Transportability

The LGF is designed for fixed-ground installation in a controlled environment, but it must be transported to the installation site, so a nominal vibration test shall be applied, with power OFF, before reliability testing. This vibration test shall be sufficient to verify that the LGF meets the requirements for transportability under commercial shipping conditions. The latest version of MIL-STD-810 shall be applied, citing the test procedure for basic transport, or equivalent qualification means proposed by the vendor. The design qualification transportability test shall be performed on the equipment in shipping configuration, to ensure that cards and cables are properly secured to survive transport conditions. Once the design is qualified for transportation, the vibration test shall be performed on all units subjected to reliability testing.

3.3.1.10.3 Materials, Processes, and Parts

The LGF shall meet the requirements of FAA-G-2100G, section 3.3.1 for materials, processes, and parts. Navigational aids are subjected to environmental service conditions that have been found to be detrimental to several types of material not identified in the "g" version, FAA-G-2100G, so the following sub-paragraphs apply further restrictions to the use of such materials in the design of the LGF.

a. Iron and steel. Iron and steel shall be used only when necessary to comply with strength requirements. Outside equipment enclosures, exposed to Environment III (outside conditions), shall not be made of steel. When approved for use, iron and steel shall be treated to prevent corrosion.

b. Fibrous Material, Organic. Organic fibrous material shall not be used.

c. Fungus-inert Materials. Materials used shall be fungus-inert, except within a hermetically sealed assembly. Table 3-9, Group I, lists materials that are inherently fungus-inert, and Group II lists materials that are fungus nutrient in some configurations. Materials from Group I are preferred, but when materials from Group II must be used, they shall be rendered fungus inert by compounding with a permanently effective fungicide or by suitable surface treatment. The materials shall pass the fungus test specified in ASTM G21, with no visible growth of fungus after 28 days.

d. Insulating Materials, Electrical. Insulating materials shall be selected based on meeting or exceeding the use requirements of the following: temperature endurance, moisture absorption and penetration, fungus resistance, dielectric strength, dielectric constant, mechanical strength, dissipation factor, ozone resistance, and flammability. Polyvinyl chloride insulating materials for external cables shall be in accordance with NFPA-70. Ceramics shall conform to MIL-I-10 or equivalent, and ceramic insulators shall conform to MIL-I-23264 or equivalent. Sleeving shall provide adequate dielectric strength and leakage resistance under the designated service conditions. Cast thermosetting plastic used for electrical insulation shall be in accordance with L-P-516 or equivalent. Other electrical materials having moisture absorption of greater than 1 percent shall be impregnated with a suitable moisture barrier material.

e. Lubricants. Lubricants shall be suitable for the purpose intended. Low volatility lubricants shall be used. The lubricant shall be chemically inert with respect to the materials or other lubricants it contacts. Silicone and graphite base lubricants shall not be used.

f. Rubber (natural). Natural rubber shall not be used.

g. Wood and Wood Products. Wood and wood products shall not be used inside equipment.

h. Thread Locking and Retaining Compounds. Thread locking and retaining compounds shall conform to the required operating conditions and MIL-S-22473 or MIL-S-46163 or equivalent, and shall be applied such that the required level of locking or retaining is achieved and maintained. Such compounds shall not impair electrical conductivity, cause or accelerate corrosion, or be used where failure would endanger personnel or damage equipment, and such compounds shall be compatible with the material to which they are bonded.

i. Antiseize Compounds. Antiseize compounds shall conform to MIL-T-22361 or TT-S-1732 or equivalent. Graphite base antiseize compounds shall not be used.

Table 3-9. Fungi Susceptibility of Material

GROUP I. FUNGUS-INERT MATERIALS	GROUP II. NOT FUNGUS-INERT
Acrylics	ABS (acrylonitrile-butadiene styrene)
Acrylonitrile-styrene	Acetal
Acrylonitrile-vinyl-chloride copolymer	Cellulose acetate
Ceramics	Epoxy-glass fiber laminates
Chlorinated polyether	Epoxy-resin
lenepropylene copolymer	Lubricants
(FEP)	Melamine-formaldehyde
Glass	Organic polysulphides
Metals	Phenor-formaldehyde
Plastic laminates:	Polydichlorostyrene
Silicone-glass fiber	Polyethylene, low and medium density
Phenolic-nylon fiber	(0.940 and below)
Diallyl phthalate	Polymethyl methacrylate
Polyacrylonitrile	Polyurethane (the ester types are particularly susceptible)
Polyamide	Polyrichinoleates
Polycarbonate	Polyvinyl chloride
Polyester – glass fiber laminates	Polyvinyl chloride-acetate
Polyethylene, high density (above 0.940)	Polyvinyl fluoride
Polymonochlorotrifluoroethylene	Rubbers, natural and synthetic
Polypropylene	Urea-formaldehyde
Polystyrene	
Polysulfone	
Polytetrafluorethylene	
Polyvinylidene chloride	
Sillicone resin	
Siloxane-polyolefin polymer	
Siloxane-polystyrene	

Note: Under certain conditions, polyamides may be attacked by selective micro-organisms.

3.3.1.10.4 Electromagnetic Compatibility

In addition to the requirements of Section 3.3.2 of FAA-G-2100G, for electromagnetic compatibility (EMI/EMC), the LGF shall meet the following requirement.

For all equipment that radiates in the frequency bands protected for radio navigation, the vendor shall meet the requirements of 47 CFR 87 (Telecommunications, Federal Communications Commission, Part 87, Aviation Services) of the FCC Rules and Regulations.

3.3.1.10.5 FCC Type Acceptance and Registration

The first article production LGF equipment shall be subjected to FCC type acceptance and registration procedures in accordance with the Federal Communications Commission (FCC) Rules and Regulations in the Code of Federal Regulations CFR, Title 47, Part 2, 15, 87, and if applicable, 68. The environmental temperature range specified by the FCC shall supersede, for the purposes of the FCC Type Acceptance Procedures, the service conditions temperature range, which is applicable under this specification.

3.3.1.10.6 Connector and Cable Marking for Maintainability

All connectors and cables that are used for maintainability shall be clearly labeled or marked by work labels descriptive of their specific function, purpose, and configuration item identification. This marking shall be reflected in the appropriate maintainability documentation (TI-Manual, Standard Installation Drawings, etc.).

a. Connectors shall be keyed to prevent inappropriate connection. Pin-outs shall be identified clearly identified ensure the ability to troubleshoot.

b. Cables shall be color-coded when required for maintainability.

c. All radio-frequency connectors furnished on the equipment for the purpose of making external connections shall be clearly identified on the plug-in side by work labels descriptive of their specific function (e.g., AND, IF INPUT, RF OUTPUT, etc.)

3.3.1.10.7 Warning and Caution Labels

The type or category of hazard to personnel shall be indicated to facilitate accident avoidance.

3.3.1.10.8 VDB and Reference Receiver Antenna Masts

3.3.1.10.8.1 Antenna Mast Frangibility

The RR and VDB antenna shall be designed to be mounted using either a frangible or non-frangible mast. Antenna masts located within the airport safety areas (Runway Safety Area, Object Free Area, and Obstacle Free Zone) shall be frangible in accordance with FAR part 139, Certification and Operation: Land Airports Serving Certain Air Carriers; and AC 150/5300.13, Airport Design. Frangible masts shall include break-away mechanisms with the following requirements:

a. The structure shall be designed and constructed to absorb no more than 700 foot-pounds of impact energy.

b. If any member exceeds four (4) feet in length, additional break-away joints shall be provided.

c. The maximum spacing of the break-away mechanisms shall be four (4) feet.

d. To achieve maximum frangibility, the break-away mechanisms shall be applicable to all members regardless of their geometric orientation.

e. The electronic equipment and components shall be designed and constructed with break-away mechanisms, provided that the operational functions are not degraded.

3.3.1.10.8.2 Antenna Height

The reference receiver and VDB antennas shall be designed to be mounted on masts with a height of 3 feet to 50 feet.

3.3.2 CONTROL AND DISPLAY

All control and display units shall be in accordance with Human Factors guidelines, defined in Section 3.3.6 of FAA-G-2100G and Sections 7 and 8 of the Human Factors Design Guide. In the event of a conflict within these documents, the Human Factors Design Guide shall take precedence.

3.3.2.1 Local Status Panel

3.3.2.1.1 LSP – Modes and Service Alerts

The LSP shall annunciate LGF operating status as follows:

a. Green for Normal,

b. Red for Not Available,

c. White for Test, or

d. Orange for Service Alert.

The LSP shall display a change in mode and service alerts within 2 seconds of detection by the LGF.

3.3.2.1.1.1 LSP – Initialization

The LSP shall simultaneously annunciate green, red, white, and orange during a power-up, manual reset, or automatic restart, as a test to ensure all indicators are displaying properly. The LSP shall have a legible label to denote panel indicator functions.

3.3.2.1.2 LSP – Aural Signal

The LSP shall initiate a steady tone aural signal when the LGF is Not Available. The LSP shall initiate an intermittent beep aural signal when there is a service alert. Annunciating "Not Available" shall take precedence over a service alert. Aural signals shall be implemented in accordance with FAA Human Factors Design Guide Sections 7.3.1.5, 7.3.1.6, 7.3.2 (excluding Sections 7.3.2.1.1 through 7.3.2.2.5), 7.3.3, and 7.3.4.

3.3.2.1.3 LSP – Silence Switch

Upon command, the LSP shall manually silence an aural signal. The LSP shall automatically reset the signal, once it has been silenced, until another alarm, or service alert.

3.3.2.2 Maintenance Data Terminal

The MDT shall support the Universal Serial Bus (USB) interface revision 1.1 or higher. The MDT shall be capable of supporting internal or external data storage device(s). The external data storage device shall be connected to the MDT through a standard USB port.

All manually entered data shall be stored in LGF NVM.

The MDT shall be capable of storing information on a 3.5-inch floppy disk drive with standard capacity.

The MDT shall be capable of supporting an internal or external data storage device(s) through a standard Universal Serial Bus (USB) interface in accordance with IEEE 1394-1995, IEEE Standard for a High Performance Serial Bus. The data storage device shall use a removable magnetic or optical media capable of storing no less than 250 megabytes (MB) of data.

The MDT shall include a computer virus check for malicious code. This virus check shall be performed on any data to be transferred to the LGF via the MDT before transferring the data to the LGF. Malicious code is defined as an unauthorized attempt to include software or firmware that is capable of corrupting the operation of the LGF. The MDT shall command and monitor all test and maintenance actions available through the interface.

3.3.2.2.1 Restart

Upon command, the MDT shall restart the LGF. Commanding restart shall cause all program variables and all software and firmware-controlled hardware to be initialized to a pre-defined condition upon entering the Normal Mode.

3.3.2.2.2 States and Modes Display

The MDT shall display the current LGF state and mode, defined in Section 3.1.4.

3.3.2.2.3 Alerts and Alarm Display

The MDT shall display, within 2 seconds, all alert and alarm messages generated by the LGF.

3.3.2.2.4 VDB Display

The MDT shall display the status of all VDBs as either transmitting or not transmitting. The MDT shall display the VDB message type and data fields. The MDT shall display the VSWR of each of the VDB transmitter(s).

3.3.2.2.5 VDB Control

Upon command, the MDT shall activate and deactivate the VDB transmission to any VDB antenna. VDB deactivate shall by-pass the VDB antenna and terminate into a dummy load.

3.3.2.2.6 VDB Message Data

Upon command, the MDT shall allow adjustment of the following VDB message data for each message type and parameter:

a. Message Header
    1. Reference Station ID
b. Type 1 Message
    1. Measurement Type
    2. Sigma Pseudorange Ground (Section 3.2.1.2.8.7)
    3. Ephemeris Decorrelation Parameter
c. Type 2 Message
    1. LGF Installed RRs
    2. LGF Accuracy Designator
    3. Local Magnetic Variation
    4. Refractivity Index
    5. Scale Height
    6. Refractivity Uncertainty
    7. Latitude
    8. Longitude
    9. Reference Point Height
    10. Sigma Ionosphere
    11. Reference Station Data Selector
    12. Maximum Use Distance

13. Ephemeris Fault-Free Missed Detection Parameters

d. Type 4 Message

1. Data Set Length
2. FAS Data Block - manually entered as a block in its entirety:
    a) Operation Type
    b) SBAS Provider Identification
    c) Airport Identification
    d) Runway Number
    e) Runway Letter
    f) Approach Performance Designator
    g) Route Indicator
    h) Reference Path Data Selector
    i) Reference Path Identifier
    j) LTP/FTP Latitude
    k) LTP/FTP Longitude
    l) LTP/FTP Height
    m) Δ FPAP Latitude
    n) Δ FPAP Longitude
    o) Approach TCH Height
    p) Approach TCH Unit Selector
    q) GPA
    r) Course Width
    s) Δ Length Offset
    t) FAS CRC
3. FAS VAL
4. FAS LAL

3.3.2.2.7 System Power Display

The MDT shall display the LGF power source.

3.3.2.2.8 Alerts and Alarm Status Display

The MDT shall display the status of all existing alerts and alarms.

3.3.2.2.9 Alerts and Alarm Threshold Display

Upon command, the MDT shall display the thresholds and tolerances for alert, service alert, constellation alert, and alarm parameters used in the generation of alerts and alarms in Sections 3.1.5.1.2, 3.1.5.1.3, 3.1.5.1.4, 3.1.5.1.5, 3.2.1.2.8.5.6.1, 3.2.1.2.8.6.1, and 3.2.1.2.8.8.1.

3.3.2.2.10 Alerts and Alarm Threshold Control

Upon command, the MDT shall enable the modification of the thresholds for alert, service alert, constellation alert, and alarm parameters, used in the generation of conditions identified in Sections 3.1.5.1.2, 3.1.5.1.3, 3.1.5.1.4, 3.1.5.1.5, 3.2.1.2.8.5.6.1, 3.2.1.2.8.6.3, and 3.2.1.2.8.8.1. Upon command, the MDT shall enable the modification of the defined thresholds, in minimum steps, within design tolerances. The MDT shall enable the manual input of all pre-defined thresholds within the design tolerances.

3.3.2.2.11 Monitor By-Pass

3.3.2.2.11.1 By-Pass Annunciation

Upon command, the MDT shall by-pass the aural annunciation of all alerts and alarms to the LSP or ATCU, or all simultaneously while the LGF is in the Test Mode. The MDT by-pass annunciation function shall have a configurable default setting.

3.3.2.2.11.2 By-Pass Actions

Upon command, the MDT shall by-pass the VDB shutdown action associated with Section 3.2.3 item (b).

Note: This capability is provided for maintenance purposes.

3.3.2.2.12 Static Site Data Display

Upon command, the MDT shall display the following site-specific parameters:

a. Transmitter Frequency,
b. Measured power of each VDB,
c. TDMA Time Slot(s) of each VDB,
d. RR Geodetic Coordinates, and
e. Reception Mask.

3.3.2.2.13 Static Site Data Control

Upon command, the MDT shall enable the input of the following site-specific parameters:

a. VDB Frequency of each transmitter, 108.025 MHz to 117.950 MHz in 25 kHz channels,

b. VDB Power Adjustment of each VDB,

c. TDMA Time Slot(s) of each VDB,

d. RR Geodetic Coordinates (WGS-84), and

e. Reception Mask.

3.3.2.2.14 Approach Status Display

The MDT shall simultaneously display the approach status for up to 16 runway ends. The MDT shall display the enable, disable, and Lateral Navigation (LNAV) status of each runway end supported by the LGF.

3.3.2.2.15 Approach Control

Upon command, the MDT shall enable any approach associated with each runway end served by the LGF. Upon command, the MDT shall disable any approach associated with each runway end served by the LGF.

3.3.2.2.15.1 LNAV Only Approach

Upon command, the MDT shall enable LNAV only for any approach associated with each runway end served by the LGF. Upon command, the MDT shall disable LNAV only for any approach associated with each runway end served by the LGF.

3.3.2.2.16 Redundant Equipment Status Display

The MDT shall display the status for both classifications of LGF equipment, Main and Standby. Main and Standby equipment and the possible status shall be:

a. Main – Primary LGF Equipment

   1. On-line – Primary LGF equipment is on-line and operational.
   2. Failed – Equipment has failed and is not available for operational use.
   3. Disabled – Equipment has been disabled.

b. Standby – Backup/redundant LGF Equipment

   1. Available – Equipment is functional and is available for switchover following a main equipment failure.
   2. Failed – Equipment has failed and is not available for operational use.

3. Disabled – Equipment has been disabled.
4. On-line – Backup/redundant LGF equipment in on-line and operational.

3.3.2.2.17 Redundant Equipment Control

Upon command, the MDT shall change the classification of the LGF equipment as indicated in Section 3.3.2.2.16.

3.3.2.2.18 Diagnostics Display

The MDT shall display diagnostic results following a failure or a manual initiation. The MDT shall have on-screen-help in order to perform diagnostics and other maintenance related actions.

3.3.2.2.19 Diagnostics Control

The MDT shall enable manually initiated diagnostics. This shall include both Non-intrusive and Intrusive maintenance actions, as follows:

a. Non-intrusive diagnostics do not affect the current LGF operation.
b. Intrusive diagnostics may affect the LGF operation or require a re-certification Flight Check.

3.3.2.2.20 Temperature Display

The MDT shall display the temperature inside and outside of the LGF equipment facility.

3.3.2.2.21 Adjustment Storage

Before log-off, MDT-entered settings and adjustment shall be confirmed and the values stored in LGF NVM.

3.3.2.2.22 Processing and Memory Load Display

The MDT shall display the processor and memory loading factors, and error sensing and reporting, as defined in Section 3.3.1.2.

3.3.2.2.23 Logons Display List

Upon logon, the MDT and NIMS shall display all active LGF maintenance users.

3.3.2.2.24 Aircraft Accuracy Designator

Upon command, the MDT shall enable input of the Aircraft Accuracy Designator. Upon command, the MDT shall display the Aircraft Accuracy Designator stored in the NVM.

3.3.2.2.25 Azimuth/Elevation Sector

Upon command, the MDT shall enable inputs of the Azimuth/Elevation sector masks. Upon command, the MDT shall display the Azimuth/Elevation sector masks stored in the NVM.

3.3.2.3 Air Traffic Control Unit (ATCU)

The LGF configuration shall include a primary ATCU and at least one secondary ATCU. The ATCU shall be designed as an external interface, which can support operations at control towers and terminal and en route radar facilities located up to 3000 miles from the LGF. The ATCU shall work with up to 10 secondary ATCUs. The primary and secondary ATCUs shall be identical in form, fit, and function.

3.3.2.3.1 ATCU - Approach Control

Upon command, the ATCU shall simultaneously enable all approaches associated with any individual runway end served by the LGF. Upon command, the ATCU shall simultaneously enable all approaches associated with any individual runway end at a single airport. Upon command, the ATCU shall enable or disable all approaches to a runway end with a single action. The ATCU shall be site adaptable to each airport landing runway configuration. Upon command, the ATCU shall display up to six (6) landing runway configurations in accordance with the airport's runway use plan. Upon command, the ATCU shall enable/disable approaches for each landing runway configuration. A landing runway configuration is a unique pattern of active and inactive runway ends.

3.3.2.3.2 ATCU – Operational Status Display

The ATCU shall display the current enabled approach ends, including LNAV only, in the status display screen. The primary status display screen shall be the initial system entry screen when eight (8) or less runway ends are active. It shall display the designators of up to eight (8) active runway ends. If more than eight (8) runway ends are active, the secondary status display screen shall be the default display. The secondary status display screen shall display all runway end pairs [up to sixteen (16)] with active runway ends highlighted. The ATCU shall display "LNAV Only" when the vertical guidance for a runway end is disabled.

The ATCU shall display the failure of any VDB subsystem that does not meet minimum coverage requirements at a given runway or runways. The ATCU shall also display all runway(s) affected by VDB subsystem failures.

3.3.2.3.3 ATCU – Control Display

The ATCU control display shall:

a. Enable the selection and deselection of active runway ends, and

b. Enable release and request for the "Primary ATCU" control.

3.3.2.3.4 ATCU - Modes

The ATCU shall display "Not Available-Alarm", corresponding to the Not Available Mode defined in Section 3.1.4.4. The ATCU shall display "Not Available-Power Off at LGF" when the LGF is in the Off State. The ATCU shall display changes in modes within 2 seconds of detection by the LGF.

3.3.2.3.5 ATCU - Maintenance Display

When the LGF is in the Test Mode, the ATCU shall simultaneously display “Test” and “Not Available.”

3.3.2.3.6 ATCU Alert Display

The ATCU shall display a constellation alert within 2 seconds from the time of prediction. The ATCU shall display the start time and the end time of the predicted outage. The ATCU shall indicate when the service is available.

3.3.2.3.7 Aural Signal

The ATCU shall initiate a brief (like a “chirp”), intermittent (approximately every 1.5 seconds) aural signal for all LGF mode changes. The ATCU shall initiate a brief, intermittent aural signal for all three stages of a constellation alert: the initial warning of constellation loss, the actual constellation loss, and when the service becomes available. The ATCU shall initiate a brief, intermittent aural signal for loss of VDB coverage to any runway(s) because of VDB subsystem failure. The aural signals sounded by the ATCU shall not change in pitch, as measured in cycles per second. Aural signals shall be implemented in accordance with FAA Human Factors Design Guide, Sections 7.3.1.5, 7.3.1.6, 7.3.2 (excluding Sections 7.3.2.1.1 through 7.3.2.2.5), 7.3.3, and 7.3.4.

3.3.2.3.7.1 Audio Control

The ATCU shall manually control an aural signal with a range from low, but not silenced, to audible over ambient noise levels. Ambient noise levels in current controller environments range between 63 and 79 dB, with a mean of 67.7 dB. The ATCU shall have a switch, to be labeled “Acknowledge,” that acknowledges, silences, and resets the aural signal until a change in mode, or a constellation alert occurs.

3.3.2.3.8 Design Requirements

The ATCU design shall have transfer and lockout control between the primary ATCU and the secondary ATCUs. All ATCUs shall be configurable to lock out control functions and provide status display only. All ATCUs shall have visual and aural annunciation for changes and updates of LGF status information.

3.3.2.3.8.1 Monitor Design Requirements

The ATCU monitor shall comply with the following requirements:

a. Configurable for the following physical environments, including:
   1. Rack-mounted in standard 19" equipment racks,
   2. Flush-mounted into the control tower console, terminal radar approach control (TRACON), and air route traffic control center (ARTCC), and
   3. Set-up as an independent workstation.

b. Display screen attributes:
   1. Diagonal color flat screen LCD, between 14” and 15.1”,
   2. A resolution of at least 800 x 600 pixels and 72 Dots Per Inch (dpi),
   3. Refresh rate of more than 70 Hz,
   4. Viewing angle at least 160° in vertical and horizontal planes,
   5. Equipped with a touch screen input, in accordance with the guidelines of the Human Factors Design Guide, Section 8.8.4.2
   6. Visible under all control tower lighting conditions, including direct sunlight and night operations,
   7. Luminescence rating ranging from ≥ 40 nits to ≤ 900 nits, and
   8. Anti-glare treatment that does not reduce available light to less than 800 nits at the highest brightness setting.

c. External components and controls, including:
   1. Speaker,
   2. Volume control, and
   3. Brightness control.

The luminescence rating for the ATCU monitor shall be verified under actual operating conditions.

The ATCU monitor shall default to a standard resolution of not less than 800 x 600 pixels in the event of a power failure. The ATCU monitor shall store the last used resolution internally. The ATCU monitor shall store configuration and calibration settings for resolution when the LGF performs a cold boot.

3.3.2.4 NAS Infrastructure Management System (NIMS)

The LGF-to-NIMS interface, either embedded or via a proxy agent, shall be developed on the NAS-IR-51070000, “Interface Requirements Document for NIMS Manager/Managed Subsystem”.

The LGF-to-NIMS interface shall be configurable for monitoring only and/or maintenance control capability exclusively at the LGF via an MDT. The interface shall be developed to initially limit NIMS functions to monitoring-only capability. Future monitoring only and/or maintenance control configurations shall be in accordance with the logical access controls stated in Section 3.3.1.8.1.2.2, to permit limited write capability, depending on the criticality of the control function to be performed as stated in Section 3.3.2.4.2.

3.3.2.4.1 Monitoring Operations

The LGF-to-NIMS interface shall provide all monitoring functions, as specified in Section 3.3.2.2.

3.3.2.4.1.1 User Monitor

The LGF-to-NIMS interface shall report all users logged onto the LGF and corresponding security level.

3.3.2.4.2 Control Operations

The LGF-to-NIMS interface shall provide all control functions, as specified in Section 3.3.2.2.

3.3.2.4.2.1 Command Execution

When applicable, the LGF-to-NIMS interface shall provide a response to all control operations with a command result and an indication of command execution.

3.3.2.4.3 Communications

3.3.2.4.3.1 Protocol

The NIMS communications protocol shall be an Open Systems Interface in accordance with NAS-IC-51070000-2 (SNMPv3).

3.3.2.4.3.2 Management Information Base (MIB) Information

The NIMS manager addresses and processes the information received from the LGF (embedded or proxy agent). The NIMS manager performs the functions of monitor and control on these data.

3.3.2.4.3.3 Dedicated Communications Line

The LGF-to-NIMS interface shall communicate directly to the NIMS manager via a dedicated communications line. The dedicated line shall be capable of T1 and dial-up service.

3.3.2.4.3.4 Connection Speed

The LGF-to-NIMS interface connection, via an internal modem, shall include adjustable speeds of 2.4, 4.8, 9.6, 19.2, and 33.6 Kbps.

3.3.2.4.3.5 Asynchronous Connections

The LGF-to-NIMS interface connection, via an internal modem, shall provide for asynchronous connections with full duplex transmissions.

3.3.2.4.4 Industry Software

3.3.2.4.4.1 Commercial Software Tools

The LGF-to-NIMS interface shall use commercially available software tools for the development and coding of the operational software.

3.3.2.4.4.2 Non-Proprietary Operating System

The LGF-to-NIMS interface shall use a Non-Proprietary Operating System for the embedded or proxy agent.

3.3.2.4.4.3 Point-to-Point Protocol (PPP)

The LGF-to-NIMS interface shall use a version of PPP communications software, or an internal PPP capability, for communications.

3.3.3 RECORDING

Filtering of repetitive events shall be permitted, with the most recent event logged with an indication of the start of the event. Commands to write over or delete any of the data sets in Sections 3.3.3.1, 3.3.3.2, 3.3.3.3, and 3.3.3.4 shall not be permitted. The LGF NVM used to store data shall be secure at all times from tampering and manipulation.

3.3.3.1 System Events

The LGF shall maintain a chronological record in NVM of the previous 90 days of date, time, inside and outside temperature, log-on, log-off, alert, service alert, constellation alert, and alarm events. The MDT shall display system event records.

3.3.3.2 Events Recording

The LGF shall use the data from the sigma monitor, Section 3.2.1.2.8.7.3, to indicate the hourly, daily, monthly, and yearly characteristics of the error in the broadcast correction. The data shall be recorded in NVM and exportable to the MDT and displayed on control chart(s) that includes alerts, service alerts, alarms, and action lines.

3.3.3.3 VDB Recording

The LGF shall automatically record all data broadcast parameters for a period not less than 48 hours. This data shall be exportable via a standard, commercially available electronic media. One 48-hour block of data shall be stored in NVM concurrently while the current 48-hour block of data is being recorded. At the end of each 48-hour period, the data stored from the previous 48 hours can be deleted and replaced with the current block of data. Four time windows for one, 24-hour period shall be selectable to capture any requested VDB field(s). This shall be programmable for up to one-week prior, and shall not interfere with the other recording requirement.

3.3.3.4 Reference Receiver Data

The LGF shall automatically record RR data for all RRs for a period not less than 48 hours. This data shall be exportable via a standard, commercially available electronic media. One 48-hour block of data shall be stored in NVM concurrently while the current 48-hour block of data is being recorded. At the end of each 48-hour period, the data stored from the previous 48 hours can be deleted and replaced with the current block of data. Recorded RR data shall include at a minimum:

a. L1 carrier phase with a resolution of 0.01 cycles,

b. L1 C/A code pseudorange with a resolution of .01 meter or better, and

c. Broadcast navigation data for all tracked GPS ranging sources.

Upon command from the MDT, the recording function shall be terminated for a period not to exceed 30 minutes.

3.3.4 INTERFACE REQUIREMENTS

3.3.4.1 LSP Interface

The vendor shall define all LSP data interface requirements. The interface characteristics shall be commercially available and in accordance with ISO standards and recommendations.

3.3.4.2 ATCU Interface

The vendor shall define all ATCU and secondary ATCU interface requirements. The interface characteristics shall be commercially available and in accordance with ISO standards and recommendations.

4. VERIFICATION

4.1 TEST PROGRAM

The testing and test activities of inspection, analysis, and demonstration assure that LGF hardware, software, and system requirements have been fully satisfied in accordance with the Acquisition Management System Test & Evaluation Process Guidelines (FAA, July 1997). These guidelines minimize reliance on explicit policies defining the conduct of test and evaluation. Practical testing appropriate to each acquisition is strongly supported. The qualification requirement verification process specified herein is in accordance with the guidelines.

Operational Test (OT) shall be conducted in support of the acceptance of the LGF in accordance with the requirements of this specification. OT is normally conducted with contractor support at the designated FAA test facility; the FAA William J. Hughes Technical Center (WJHTC). Development Test (DT) and Production Acceptance Test (PAT) shall be performed at the contractor facility and shall reference the Verification Requirements Traceability Matrix (VRTM) in Appendix C. Site Acceptance Test (SAT) is performed at each installation and shall reference the VRTM in Appendix C.

4.1.1 GENERAL TESTING REQUIREMENTS

4.1.1.1 Development Test

DT activities shall be conducted to verify that the implemented hardware and software design meet the functional and performance requirements of the LGF specification. Specific tests for verification are not conveyed, but normally include the verification of software and hardware requirements, stability and dry running, and system level testing.

4.1.1.2 Production Acceptance Test

PAT shall be performed on each end-item before it leaves the factory to verify that the end-item conforms to applicable requirements, is free from manufacturing defects, and is substantially identical to the qualified system.

4.1.1.3 Site Acceptance Test

SAT is conducted after completion of hardware installation and checkout, and the installation has been inspected and approved for workmanship and configuration. SAT is accomplished initially for the developmental system, and is repeated for each production system after PAT. For Low Rate Initial Production (LRIP) units, the contractor-conducted testing shall be performed at each field site to verify that the new system is installed and operating properly on site.

4.1.1.4 Verification Methods

The LGF Test Program shall use the verification methods of Inspection (I), Analysis (A), and Test (T). These methods are defined as follows:

a. I – Inspection is a method of verification to determine compliance with specification requirements and consist primarily of visual observations, mechanical measurements of the equipment, physical locations, and technical examination of engineering-supported documentation.

b. A – Analysis is a method of verification that consists of comparing hardware or software design with known scientific and technical principles, technical data, or procedures and practices to validate that the proposed design will meet the specified functional and performance requirements. Analysis also includes the use of modeling and simulation.

c. T – Test is a method of verification that will measure equipment performance under specific configuration-load conditions and after the controlled application of known stimuli. Quantitative values are measured, compared against previous predicted success criteria, and evaluated to determine the degree of compliance.

4.1.2 RELIABILITY TEST

A reliability test shall be conducted in accordance with test plan IV-D, MIL-HDBK-781A. The test shall consist of testing at least two (2) LGFs, as defined in Section 3.3.1.1.1, excluding antenna assemblies, for a minimum of 1000 hours each. One half of the test shall be performed at 25 degrees Centigrade, one fourth at 50 degrees Centigrade and one-fourth at Minus 10 degrees Centigrade. All active components installed in a Category III environment (outdoor) shall be tested at + 70^{o}C and – 50^{o}C for the high and low temperature limits. The contractor shall propose a specific temperature cycling profile as part of the reliability test procedure. The lower test MTBF (θ_1) shall be 1,095 hours. Failures shall be classified in accordance with Section 4.7 of MIL-HDBK-781A to determine relevant failures. The accept or reject decision shall be based on the criteria for test plan IV-D, as shown in Figure 12 of MIL-HDBK-781A.

Appendix A

This page intentionally left blank.

Appendix B

This page intentionally left blank.

Appendix C

Verification Requirements Traceability Matrix

Section				Requirement	Verification Level and Method			Remarks
					DT	PAT	SAT	
3.1				LAAS Ground Facility General Requirements				Section Header, No Test Requirements
3.1.1				Coverage Volume	T	T	T	
3.1.2				Integrity	A			
3.1.3				Continuity	A, T			
3.1.4				States and Modes	I	I	I	
3.1.5				Executive Monitoring	I, A, T			
3.1.6				Software Design Assurance	I, T			
3.1.7				Complex Electronic Hardware Design Assurance	I			
3.2				Data Broadcast				Section Header, No Test Requirements
3.2.1				Broadcast Data Requirements	A, I, T	I, T	I, T	
3.2.2				RF Transmission Characteristics	I, T	T		
3.2.3				RF Broadcast Monitoring	T	I		
3.3				Operation and Maintenance				Section Header, No Test Requirements
3.3.1				System Requirements				Section Header, No Test Requirements

					Verification Level and Method			
Section				Requirement	DT	PAT	SAT	Remarks
3.3.1.1				LGF Configurations	I			
3.3.1.2				Computer Resources	I, T			
3.3.1.3				Primary Power	T	T		
3.3.1.4				Supplementary Power	T	T	T	
3.3.1.4.1				Power Supply	T	T	T	
3.3.1.5				Environmental Sensors	I, T	I	I	
3.3.1.6				Fault Diagnostics	T	T	T	
3.3.1.7				Reliability, Maintainability, and Availability of LGF Equipment				Section Header, No Test Requirements
3.3.1.7.1				Maintenance Concept	I			
3.3.1.7.2				Reliability	T			
3.3.1.7.3				Maintainability	T			
3.3.1.7.4				Availability	T			
3.3.1.7.5				System Specialist workload	I, A			
3.3.1.8				Security	I			
3.3.1.9				Physical Design for Certification	A ,I			
3.3.1.10				Electronic Equipment, General Requirements	I			

					Verification Level and Method			
Section				Requirement	DT	PAT	SAT	Remarks
3.3.1.10.1				Operating Environmental Conditions	T			
3.3.2				Control and Display	I	I	I	Title
3.3.2.2				Maintenance Data Terminal	I	I	I	
3.3.2.3				ATCU	I	I	I	
3.3.2.4				NIMS (RMDT)	I	I	I	
3.3.3				Recording	I	I	I	
3.3.4				Interface Requirements	I			

Appendix D
Acronyms

A

A
: Analysis

AC
: Alternating Current

AGL
: Above Ground Level

ANSI
: American National Standards Institute

ARTCC
: Air Route Traffic Control Center

ASIC
: Application Specific Integrated Circuit

ATC
: Air Traffic Control1

ATCU
: Air Traffic Control Unit

AVS
: Additional Very High Frequency Data Broadcast Subsystem

B

BIT
: Built-in-Test

C

CAT I
: Category I operations

CIO
: Chief Information Officer

CRC
: Cyclic Redundancy Check

D

DC
: Direct Current

Dmax
: Maximum Use Distance

dpi
: Dots Per Inch

DT
: Development Test

E

EPOL
: Elliptical polarization

F

FAA
: Federal Aviation Administration

FAS
: Final Appraoch Segment

FCC
Federal Communication Commission
FPAP
Flight Path Alignment Point
FTP
Fictitious Threshold Point

G

GBAS
Ground-Based Augmentation System
GCID
Ground Continuity and Integrity Designator
GPA
Glidepath Angle
GPS
Global Positioning System

H

HOW
Hand-over-Word
HPOL
Horizontal polarization
HWCI
Hardware Configuration Item

I

I
Inspection
ID
Identification
IOD
Issue of Data
IODC
IOD Clock
IODE
IOD Ephemeris

L

LAAS
Local Area Augmentation System
LGF
LAAS Ground Facility
LNAV
Lateral Navigation
LRU
Line Replaceable Unit
LSP
Local Status Panel
LTP
Landing Threshold Point

M

MASPS
Minimum Aviation System Performance Standards
MDT
Maintenance Data Terminal

MI
Misleading Information
MIB
Management Information Base
MOPS
Minimum Operational Performance Standards
MTBCF
Mean Time Between Critical Failures
MTBF
Mean Time Between Failure
MTTR
Mean-Time-to-Repair

N

NAS
National Airspace System
NDI
Non-Developmental Item
NIMS
NAS Infrastructure Management System
NVM
Non-Volatile Memory

O

OSHA
Occupational Safety and Health Agency
OT
Operational Test

P

P
Ephemeris Decorrelation Parameter
PAT
Production Acceptance Test
PLD
Programmable Logic Device
PPP
Point-to-Point Protocol
PRC
Pseudorange Correction

R

RFI
Radio Frequency Interference
RMDT
Remote MDT
RNAV
Area Navigation
RR
Reference Receiver
RRC
Range Rate Correction
RSDS
Reference Station Data Selector
RSP
Remote Status Panel

S

SAT
Site Acceptance Test
SBAS
Satellite-Based Augmentation System
SPS
Standard Positioning Service
SSA
System Safety Assessment

T

T
Test
TCH
Threshold Crossing Height
TDMA
Time Division Multiple Access
TRACON
Terminal Radar Approach CONtrol

U

UL
Underwriters Laboratories
URA
Use Range Accuracy

V

VDB
VHF Data Broadcast
VHF
Very High Frequency
VRTM
Verification Requirements Test Matrix
VSWR
Voltage Standing Wave Ratio

W

WAAS
Wide Area Augmentation System
WJHTC
William J. Hughes Technical Center

Appendix E

Signal Deformation Threat Model

Signal deformation is defined to be any GPS ranging source that is distorted as given by the following threat model:

1. Each falling edge of the positive chips in the C/A code is delayed by Δ seconds, where $0 \leq \Delta \leq 120$ nanoseconds.

2. Each falling edge of the positive chips in the C/A code is advanced by Δ seconds, where $0 \leq \Delta \leq 120$ nanoseconds.

3. The distorted C/A code is the output of a second order linear system that has the standard C/A code as an input. The system is characterized by a damping factor, σ, and a resonant frequency, f_d, as shown:

$$\text{C/A Code} \longrightarrow \boxed{\frac{(2\pi f_0)^2}{s^2 + 2\sigma s + (2\pi f_0)^2}} \longrightarrow \text{Distorted C/A Code} \qquad (1)$$

where $f_0 = \dfrac{1}{2\pi}\sqrt{\sigma^2 + (2\pi f_d)^2}$ and (2)

s is the complex frequency used in Laplace transforms.

Each step, e_0, in the input C/A sequence results in a second order step response that is given by

$$e(t) = e_0\left\{1 - \exp(-\sigma t)\left[\cos 2\pi f_d t + \frac{\sigma}{2\pi f_d}\sin 2\pi f_d t\right]\right\}, \qquad (3)$$

for this waveform,

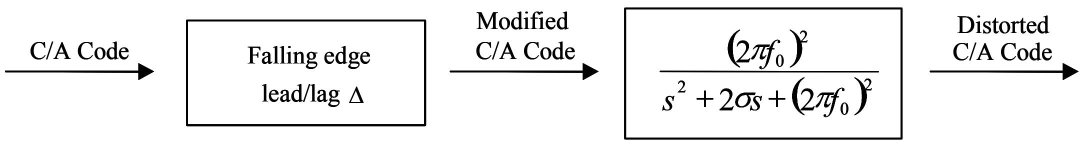
$0.8\text{x}10^6 \leq \sigma \leq 8.8\text{x}10^6$ nepers/second

$4\text{x}10^6 \leq f_d \leq 17\text{x}10^6$ cycles/second.

4. The distorted C/A code is the output of a second order linear system characterized by a damping factor and a resonant frequency with an input of a modified standard C/A code, where every falling edge of the positive chip in the modified C/A code is:

a) Delayed by Δ seconds, where $0 \leq \Delta \leq 120$ nanoseconds

b) Advanced by Δ seconds, where $0 \leq \Delta \leq 120$ nanoseconds



(4)

This waveform has the combined effects of items 1, 2, and 3, but the damping factor and resonant frequency are varied over a smaller range, specifically:

$0.8 \times 10^6 \leq \sigma \leq 8.8 \times 10^6$ nepers/second
$7.3 \times 10^6 \leq f_d \leq 13 \times 10^6$ cycles/second.

No threat of signal deformation exists for SBAS in accordance with SARPS.

The parameters are based on the airborne tracking constraints defined in LAAS MOPS.

Appendix F

Usage of LGF Test and Alarm Indicators

Several fields in the VHF data broadcast can indicate that an approach is unusable. This appendix describes those fields and how they are used.

F-1. Message Block Identifier

The message block identifier is part of the message header and is part of each message broadcast. The LGF will broadcast Type 1, Type 2 and Type 4 messages. When the message block header is 1010 1010, it is an indication that the message can be used for navigation. When the message block header is 1111 1111, it is an indication that the message cannot be used for navigation and is officially called a "Test" message. The LGF specification requires a "Test Mode" in which test conditions can be run or the system is undergoing maintenance that may cause the conditions of the LGF radiated signal to be out of tolerance. Flight inspection avionics will have the capability to override the test message block header to flight check the LGF signal without concern that the flying public may use the signal. This capability is similar to removing the ident from a VOR or ILS facility.

F-2 Blank Type 1 Messages

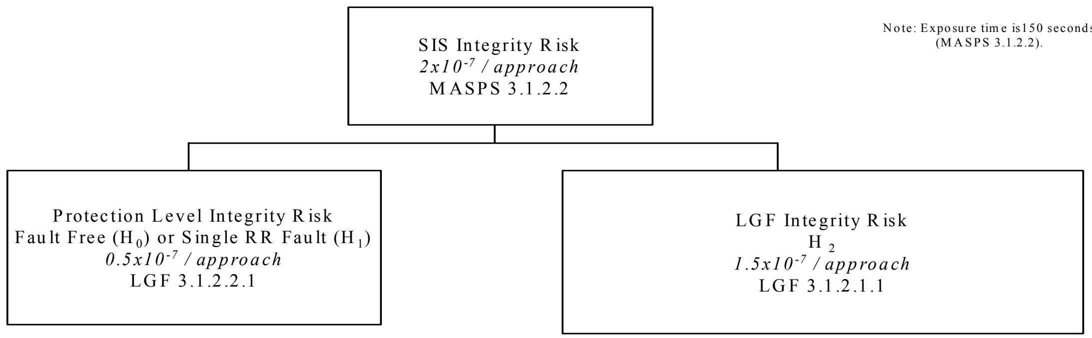
The Type 1 message provides a "Number of Measurements" field, which indicates the number of pseudorange corrections contained in the message. When this field is set to zero, the LAAS airborne receiver cannot use differential corrections from the LGF and therefore all LGF-based operations cease. This message field will be used to indicate an alarm at the LGF. The time from when the fault is detected to when it is annunciated at the aircraft includes the fact that the Type 1 message is broadcast at 2 Hz.

F-3 Ground Continuity Integrity Designator

The Ground Continuity Integrity Designator (GCID) Field is contained in the Type 2 message and indicates the operational status of the LGF. This specification addresses Category I precision approaches and indicates this with a GCID value of 1. The LGF indicates a value of 7 for the GCID when the ground station signal does not comply with the Category I requirements for integrity and continuity. It is important to note that while the LGF may be in Test mode, the LGF can change the GCID according to the actual performance level of the signal. If a fault in the LGF has been corrected, maintenance or flight inspection may prefer to perform additional checks of the system while in Test, and a true indication from the GCID of the actual performance must be provided. If the GCID is broadcasting 1, for Category I precision approach, then maintenance will be assured that corrections are included in the broadcast and not have to monitor the VDB messages. Conversely, a GCID of 7 indicates that the system is still unusable and the Number of Measurements Field has been set to zero.

Appendix G
Risk Allocation Trees

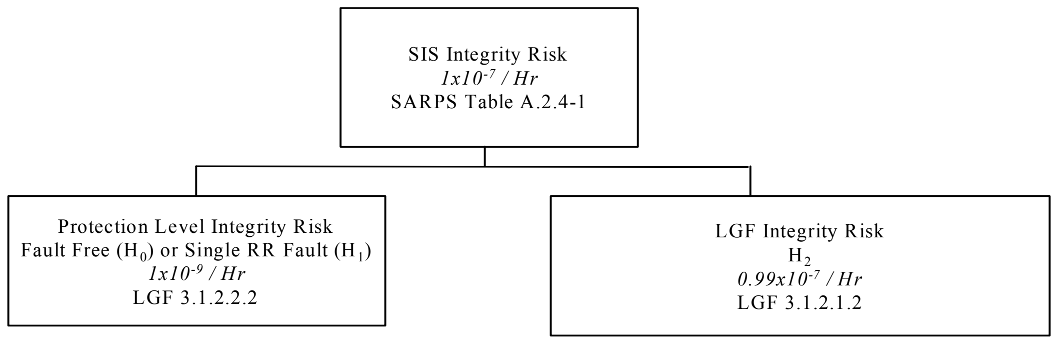
LAAS LGF Integrity Risk Allocation (Precision Approach)



Note: References to MASPS in this appendix represent RTCA/DO-245(Minimum Aviation System Performance Standards for Local Area Augmentation System, September 1998).

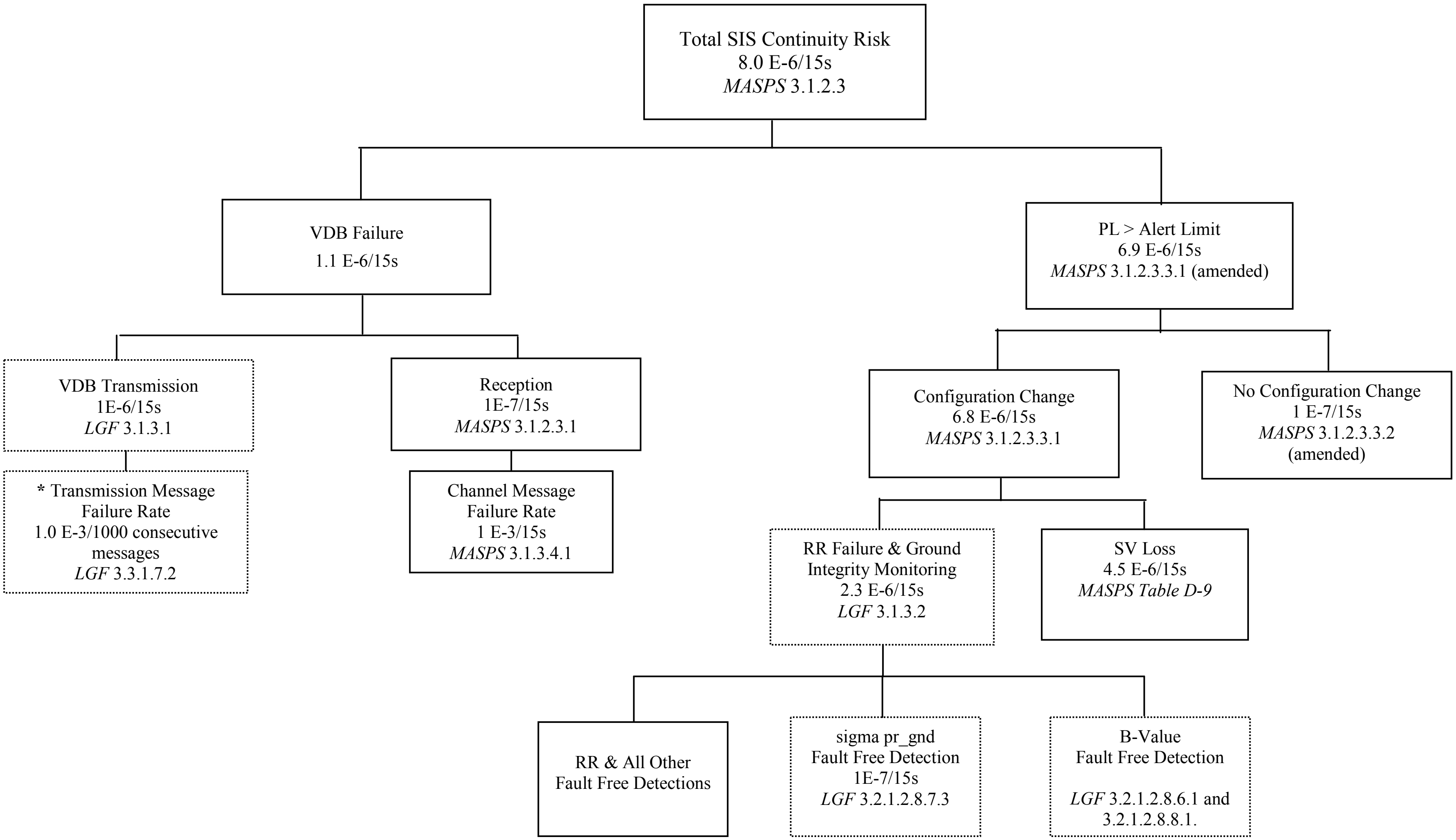
Appendix G

LAAS LGF Integrity Risk Allocation (Differentially Corrected Positioning Service)



Appendix G

Continuity Risk Allocations Continuity Risk Allocations



** Note: This is a VDB design requirement and is not specifically included to ensure continuity.*

Appendix H

Final Approach Segment – Definitions

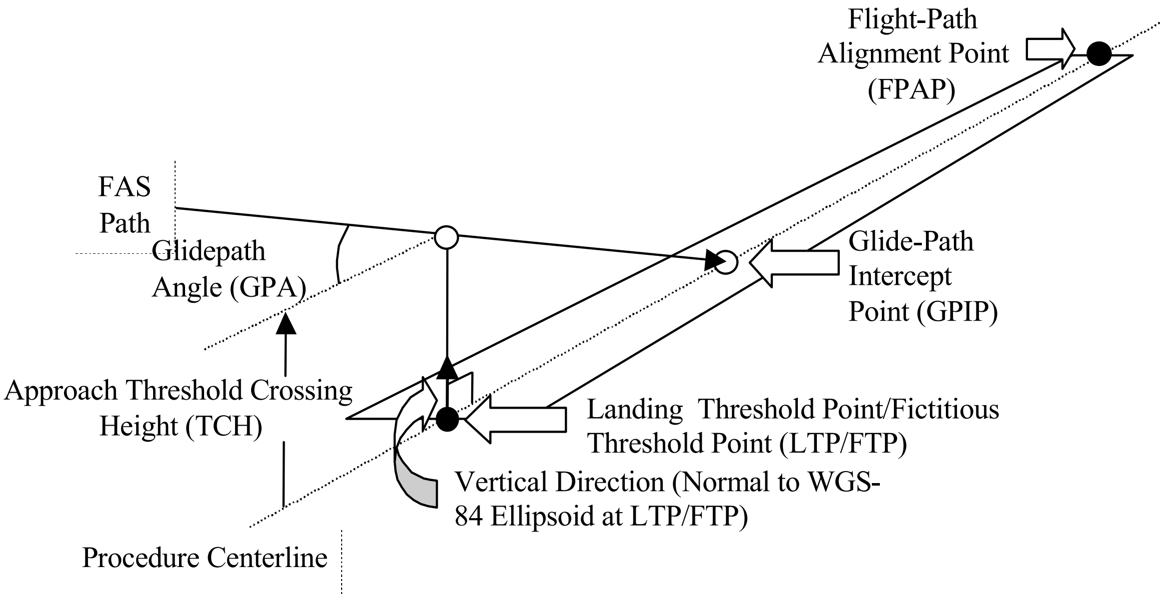


Figure H-1. Final Approach Segment Diagram

H – 1. Final Approach Segment Path Definition

The Final Approach Segment (FAS) path is a line in space defined by the Landing Threshold Point/Fictitious Threshold Point (LTP/FTP), Flight Path Alignment Point (FPAP), Threshold Crossing Height (TCH) and the Glide Path Angle (GPA). The local level plane for the approach is a plane perpendicular to the local vertical passing through the LTP/FTP (i.e., tangent to the ellipsoid at the LTP/FTP). Local vertical for the approach is normal to the WGS 84 ellipsoid at the LTP/FTP. The Glide Path Intercept Point (GPIP) is where the final approach path intercepts the local level plane.

H – 2. LTP/FTP Definition

The Landing Threshold Point/Fictitious Threshold Point (LTP/FTP) is a point over which the FAS path passes at a relative height specified by the threshold crossing height. It is normally located at the intersection of the runway centerline and the threshold.

H – 3. Final Path Alignment Point Definition

The Flight Path Alignment Point (FPAP) is a point at the same height as the LTP/FTP that is used to define the alignment of the approach. The origin of angular deviations in the lateral direction is defined to be 305 meters (1000 ft) beyond the FPAP along the lateral FAS path. For an approach aligned with the runway, the FPAP is at or beyond the stop end of the runway.